In This Issue *Regenerative Equipment for Electric Railways, Multiple-Arched vs. Single-Arched Dams, together with Departmental Discussions of Vital Interest to Engineers of the West*

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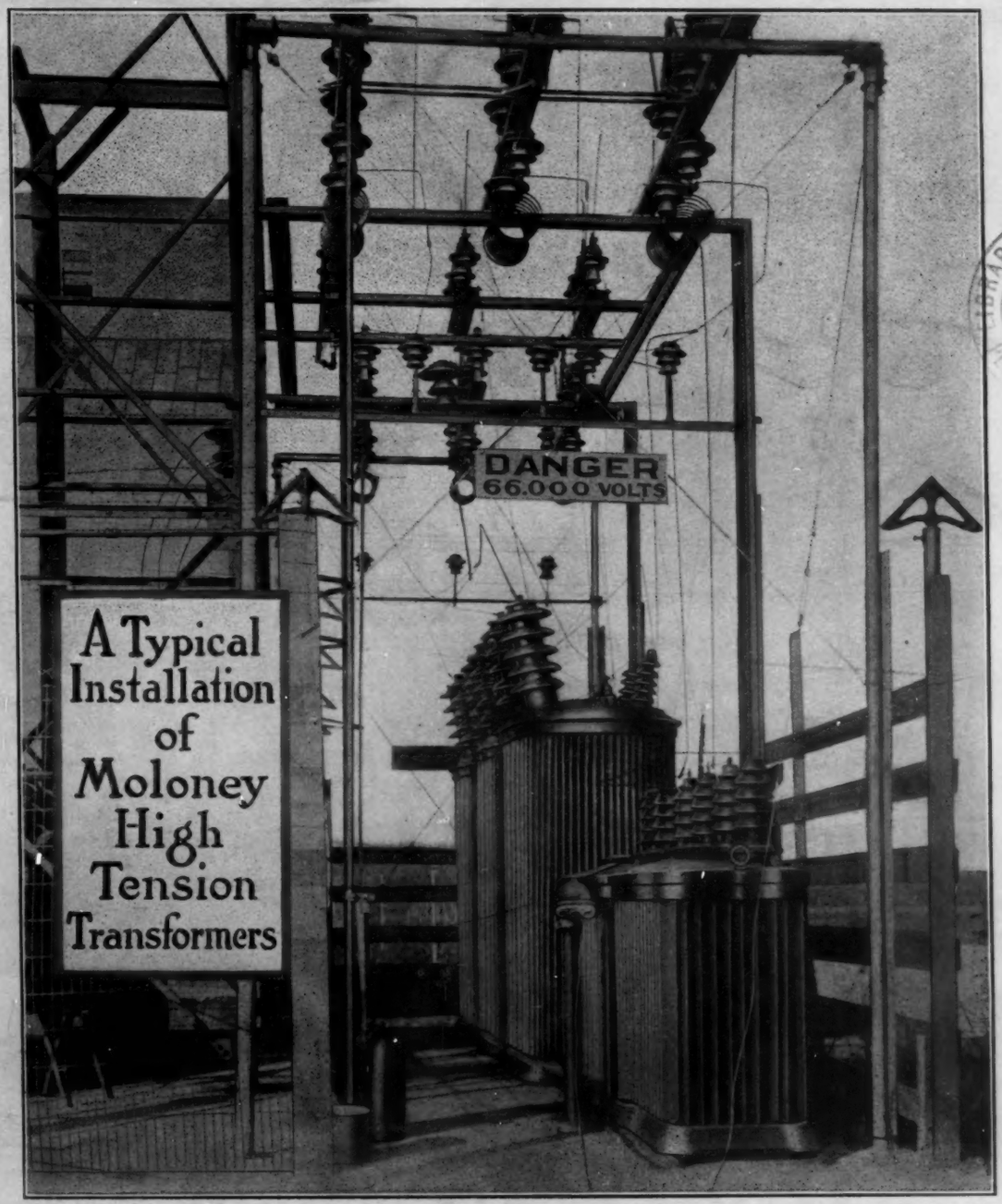

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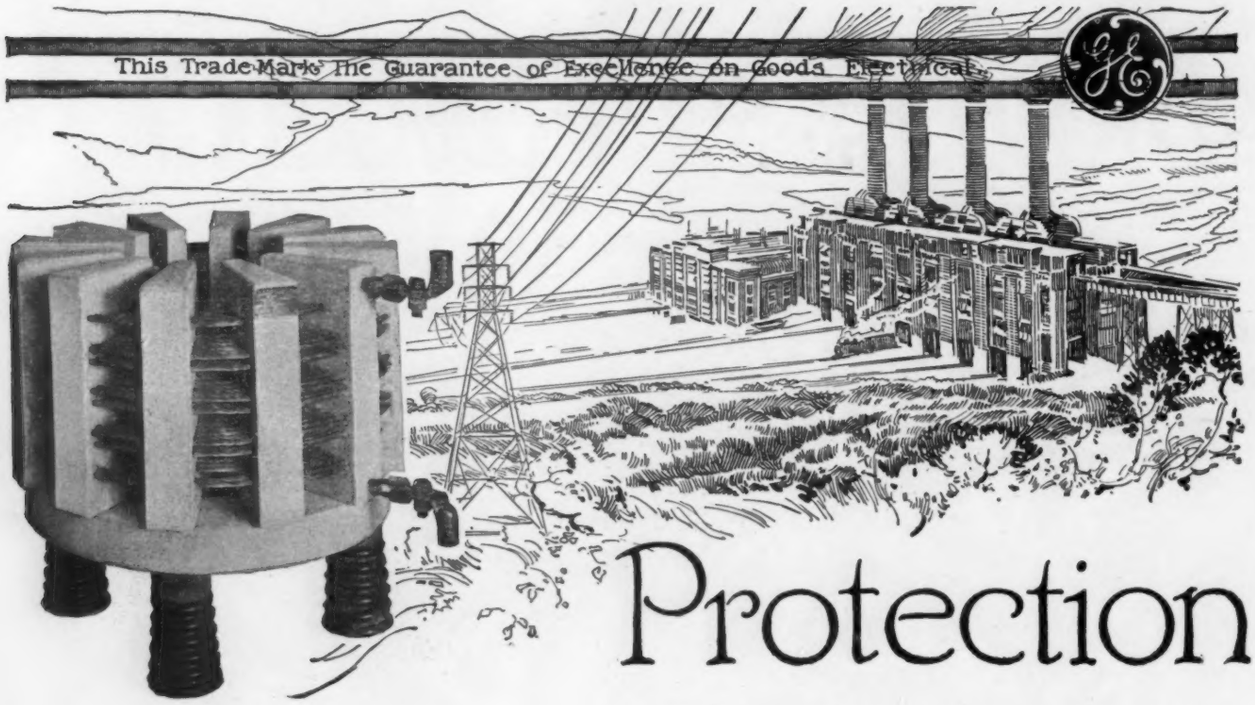

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JOURNAL OF ELECTRICITY

Devoted to the Generation, Distribution and Utilization of Energy

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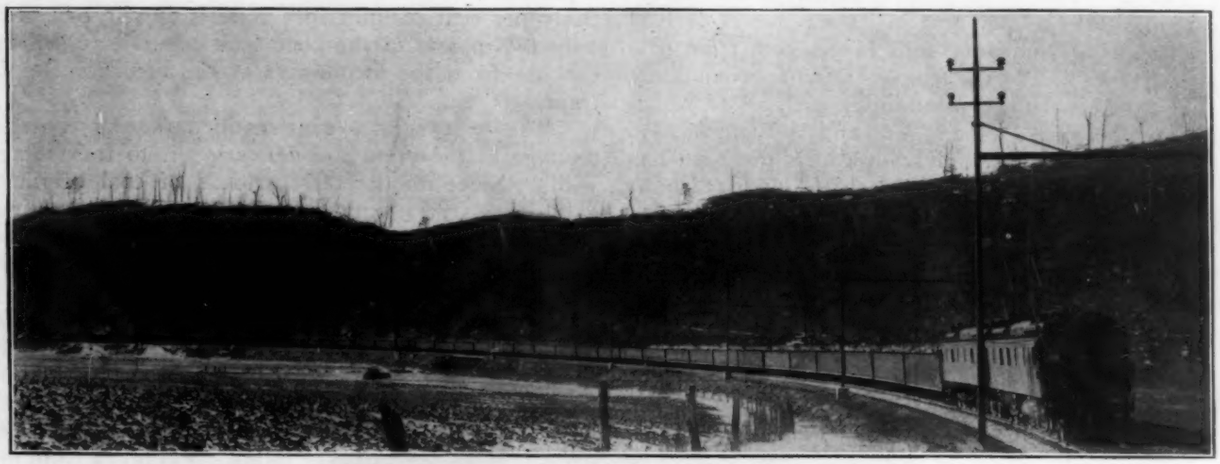
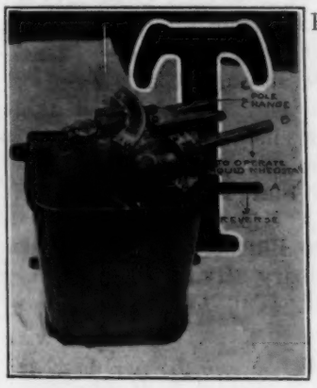


A Monster Array of "Battleships," Electrically Drawn

AN UNUSUAL RAILWAY ELECTRIFICATION

BY A. H. BABCOCK

(The whole electrical industry is alert to the possibilities of regenerative applications in the operation of electrified lines. The splendid showing that is being made by the Chicago, Milwaukee & Puget Sound Railroad through the Northwest in saving of net power consumption and ease in operation auger well for the future possibilities of regenerative methods on all transcontinental lines of the West. Here is an article, descriptive of a well-known Eastern electrification, by a Western authority on electric railway problems that, coming at this time, will undoubtedly be of intense interest to engineers of the West. The author is consulting electrical engineer for the Southern Pacific Company and delivered this paper before a recent meeting of the San Francisco Section of the American Institute of Electrical Engineers.—The Editor.)



The Master Controller

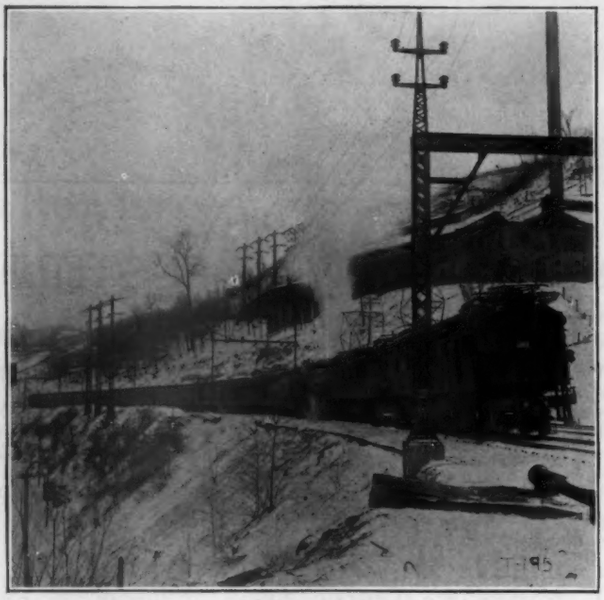
THE Norfolk & Western Railway Company covers 2050 miles of line extending from Norfolk, Va., through Roanoke and the Pocahontas coal fields, W. Va., to Columbus, O., with principal branches to Cincinnati, Bristol, Tenn., and Hagerstown, Md. The main line is double track.

In the fall of 1896 the property resumed operation, after an 18 months' receivership. This fact is stated to emphasize the point that, while at present the property is in a most satisfactory financial condition, under an exceedingly capable management, and is now noted for its progressive developments in all lines, these conditions have not been enjoyed from the first, and therefore its remarkable achievements in the past few years are altogether more noteworthy. For example, in the fiscal year ending June 30, 1915, a decrease in total operating revenue of 3.73 per cent of the year before was converted into an increase in net revenue from railway operations of 4.41 per cent, with an increase of 14.49 per cent in maintenance of way expenditures and a reduction of nearly 25 per cent in the number of cars and locomotives awaiting repairs. Ninety three per cent of its decrease in revenues was offset by a reduction in transportation expenses, and at the same time the operating ratio was reduced from 67.49 per cent to 64.74 per cent. An even more unusual showing was made during the last fall and winter, where the operating revenues were increased 37 per cent over those of the year before; the net operating revenue increased 69 per cent, and the net income was increased 96 per cent. During these months an increase of 37 per cent in freight traffic was handled, with only a 10 per cent increase in transportation expenses; and the operating ratio was re-

duced from 66 per cent of the year before to 56.9 per cent. These figures, truly remarkable, are an index of the character of the present management.

It should be remembered that the Norfolk & Western was the first road to adopt the Mallet type of locomotive for general road service on low grade lines. In 1913 it placed in operation at Norfolk the largest steel coal pier on the Atlantic seaboard; and this road was the first to use 100-ton capacity cars in coal service. Detailed mention of the steel coal pier and the large coal cars will be made later.

Traffic.—The N. & W. is primarily a coal-carrying road. Over 85 per cent of its revenue is derived from freight as compared with 11 per cent from passenger traffic; and of the freight traffic approximately 71 per cent consists of bituminous coal, all of which originates between Graham, Va., and Williamson, W. Va., a distance of 104 miles, on which the road has a complete traffic monopoly. In this district about 2000 cars of coal and 100 carloads of coke are produced daily, by 214 mines and more than 2000 coke ovens. The largest individual area is the Pocahontas field, extending from Graham to Welch, 27 miles. This field includes 86 mines, the output of which is about 62 per cent of the total coal tonnage of the road. About 250 carloads a day go west to Columbus for movement over the Lakes via Toledo and for rail distribution through the Central West. The remainder goes east to tidewater or to points along the line for delivery to connecting lines. Even at the present extraordinary rate of production, geologists estimate that there still remain in the fields immediately tributary to these lines over 5,000 million tons of coal, or approximately 100 years' supply. In addition to this very large coal tonnage, the road handles a heavy merchandise and time freight traffic. About five time freight trains are loaded daily at Norfolk with merchandise coming by water from Eastern points and billed to Southern and Western points.



The Electric Passenger Train in Operation

Omitting for the moment a consideration of the very steep grades in the electrified zone, the remainder of the line has a ruling 0.3 per cent grade from the coal fields west to Columbus, and, with a single exception 0.5 per cent from the coal fields east to tidewater.

One Hundred Ton Car and New Coal Pier.—The coal pier and the 100-ton coal cars are a unique combination. The cars (colloquially known as "battleships") are steel gondolas of external dimensions very closely approximating a large box car. They are loaded in the coal fields by chutes from the coal breakers. At the end of their 400-mile run to tidewater they are put into a frame and capsized bodily to dump their contents into coal bunkers located in the new pier at which a 5000-ton cargo steamer is loaded in two hours.

Electrified Section.—Is that part of the Pocahontas division between Bluefield and West Forks, a distance of 29.4 miles, all of which is double track with long middle passing tracks, excepting through the Elkhorn Tunnel, where the line is single track for a distance of 3100 feet.

The grades against eastbound traffic are 1.5 and 2 per cent, with a maximum curvature of 12 degrees. Sixty per cent of the entire zone is on curves and at only two points in the zone is it possible to see the caboose from the locomotive of the ordinary freight train.

The train service consists in gathering the coal tonnage at the mine and delivering it to the storage yards. Since about 2000 carloads of coal originate daily in this very limited territory, to keep the mines in this vicinity supplied with empties and to remove the loads without delay and congestion requires a very careful organization. Possibly a brief description of a trip of this kind may give the best idea of the operating methods. The following is taken from my notes: 11:30 a.m. left Bluefield with 88 empties and after about an hour continuous run, stopped to begin to set them out. At this point a pusher set in ahead of the caboose, and for the rest of the trip was used to set out cars at the various sidings wherever these sidings could not be reached from the head end—that is, the road engine handled only those cars set out from the head end. At the west end of the electrified zone we had dropped all our empties and there picked up a 3250-ton train which we handled alone until reaching the summit helper grade, where a pusher was added. At the summit we dropped the pusher, took the train to Flat Top yard, where it was made up to 5000 tons, and with the help of a pusher we took this load to Bluefield. This trip represents very fairly the ordinary service.

The general routine of handling the engines and engine crews is about as follows: One motor with its engine crews makes two round trips per day. On pusher service a motor makes five trips pushing eastbound over the Elkhorn grade and also helps distribute empties on the westbound trips. Under steam conditions two Mallets and two engine crews made one round trip per day, and one Mallet pusher on the Elkhorn grade made three trips per day, handling the same tonnage.

Train Consist.—Full tonnage eastbound trains are handled by two motors, one at the head end and one pushing. Manifest freights use one motor pushing to assist the steam road engine. Heavy passenger trains with steam road engine have one motor helper.

The day's work runs about as follows—freight business only:

August 1st—Eastbound, 8 crews made 16 trips with 581 loads, no empties; total tonnage, 51,501. Westbound, 150 loads, 361 empties.
The Elkhorn pushers, with four crews, made 18 helper trips, and the Flat Top pushers, with one crew, made 8 helper trips.

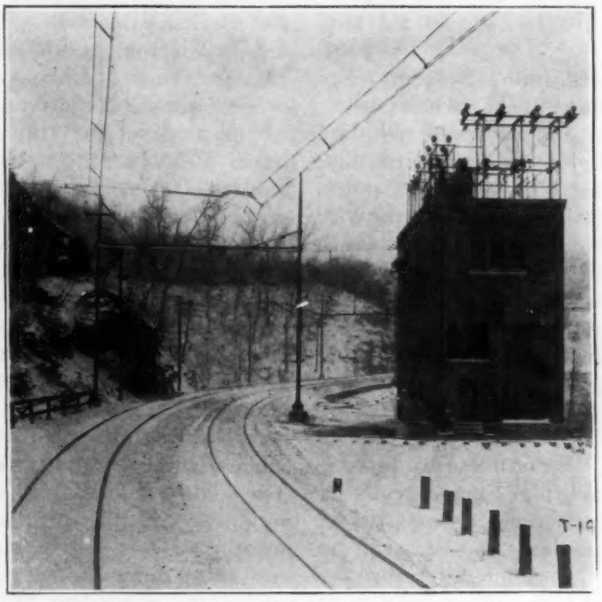
August 9th—Eastbound, 8 crews made 16 trips with 621 loads and no empties; tonnage, 51,849. Westbound, 109 loads, 320 empties.
Elkhorn pushers, 4 crews, made 19 trips.
Flat Top pushers, 2 crews, made 15 trips.

August 19th—Eastbound; total tonnage, 59,291. Westbound 171 loads, 744 empties.
Elkhorn pushers, 4 crews, made 20 trips.
Flat Top pushers, 1 crew, made 6 trips.

An extremely light day is illustrated by August 20th:
3 crews made 6 trips, 149 loads, 126 empties; total tonnage 15,857. Westbound, 33 loads, 427 empties.
Elkhorn pushers, 4 crews, made 16 trips.
Flat Top pushers, 1 crew, made 6 trips.

The real test is the annual tonnage. Eastbound freight alone is given because it is the controlling movement; the westbound tonnage is not counted because movements in that direction cannot be fully loaded. The steam service was run exclusively up to February 10, 1915; mixed, until April 14th, and full electric tonnage thereafter.

During the year 1914 and the first four months of 1915, the average trains per month was 290 and the average tonnage per month, 852,750. For the eight months, May to December, 1915—namely, the first months of all electric service—the average trains per month was 367.75 and the average tons per month, 1,135,181. Similarly for the year 1916, January to July, (my visit was in August), the average trains per month were 412.29 and the average tons per month, 1,141,402. Averages sometimes are deceiving, but it is significant to note that the average tons per train over the first period, that is to say, before electrification, was 2250, and for the few months after electrification the average was 3090, and for the first six months of the present year was 2735. The difference between the averages for 1915 and those of 1916 may be accounted for in the accident that occurred last spring, whereby for a very considerable period the station capacity was reduced to one electric train with one pusher. It is safe to say that the average train loading has been increased very approximately 33 per cent, and the average train movements, practically the same amount; in other words, the track capacity has been very nearly doubled.



A Substation Showing Typical Line Connections

Electric System.—The power house generates 25 cycle alternating current at 11,000 volts, which is stepped up to 44,000 for distribution to the substations, where it is stepped down to 11,000 and fed to the contact wires. On the locomotives it is converted and transformed to three-phase current at 725 volts, delta, by means of a split phase converter. The locomotive motors are wound for three-phase current controlled by liquid rheostats. The power station is located at Bluestone, which is 11 miles west of the east end of the electric zone. The station location was fixed by considerations governing the economic production of power. The power house has been described so many times in the technical press that detailed descriptions are not necessary. It is well to note, however, that the inherent simplicity of the single-phase distribution, combined with the skill of the designing engineers, have produced an installation well worth careful study by those who have to do with such designing.

An unusual feature of the station is the regenerative load rheostat equipment, operated automatically by a group of relays, magnetic switches, current transformers, etc., so connected that when the power regenerated by the locomotives and returned to the power house is in excess of the demands on the station, these water rheostats will cut in successively to absorb the excess load and prevent the reversing and motoring of the generators. Conversely, when the excess regenerated power is reduced to zero and only one rheostat is in service, —which means that all of the rheostat load is supplied by the generators,—the rheostat is automatically cut out, and when with two rheostats in service and the excess regenerated power drops to 200 k.v.a., one rheostat is automatically cut out while the other remains in service until the excess regenerated power drops to zero, when this cuts out automatically, as before.

The water rheostats were installed originally in the intake of the circulating canal; the movable electrode was a steel cone suspended over a six-inch iron plate located in the bottom of the canal and grounded to a copper plate imbedded in the earth outside of the canal. The rheostat was adjusted by varying the distance between the cone and the iron plate, and the ground outside of the canal prevented electrolytic damage to the concrete. After the road had been operating a few months, an improved type of rheostat was developed and is being used in place of the original. Three boxes 15 ft. long, 2 ft. square in section, were mounted on 44,000 volt pin insulators. These boxes are placed 4 ft. between centers on the ground and are connected in parallel for adequate carrying capacity. At one end,

fresh water is fed through Orangeburg fibre conduit, which is mounted on 11,000 volt pin insulators, and it flows out through numerous holes on the opposite end. Uniform velocity of waterflow throughout the entire section of the box is secured by using smaller holes at the bottom (where the pressure is greater).

The electrodes are 5-inch channel irons, 15 inches long, hung from suspension type insulators. The high pressure end is connected by 11,000 volt overhead leads with the power station, and the grounded electrodes are connected to the ground plate. Whatever adjustment of resistance is necessary to compensate for the varying conductivity of the water in different seasons of the year is obtained by shifting the electrodes horizontally in the boxes; and by reason of the small cross-section of the boxes, all necessary adjustment can be made without difficulty.

Five step-down transformer substations are installed at intervals along the line, in which are located single-phase, oil-insulated, water-cooled type transformers operating without station attendance, the necessary switching being handled by the regular railroad attendants at passenger stations, yard masters' offices, etc.

Transmission and Distribution System.—The transmission lines are two single-phase circuits using four 2/0 7-strand hard-drawn copper wires mounted on pin type insulators supported on catenary structure, except where the transmission line on wooden poles, passes over the tunnels. A ⅜-inch steel ground wire is carried above the transmission lines over the length of the line. The cross-arms on all poles are connected to the ground wire, which itself is grounded every 1200 ft. At the substations the high tension lines are sectionalized by means of air break switches located on the roofs. No supplementary feeders are necessary for the distribution system, the power supply being effected entirely by means of the contact lines. Two distinct types of supporting structures are used—namely, on the main line, light bridges made generally of tubular steel poles (guyed wherever necessary) set in concrete, which carry light steel "H" beams from which the catenary structure is suspended. Across the yards the catenary is supended from an overhead cross catenary cable strung from high poles or towers located at opposite sides of the yard. On tangents the bridges are not guyed, but in all curves guys are installed on the outside of the curves wherever there is room on the right-of-way. An unusual feature of the bridges is the use of the sag bracing instead of knee—a feature that adds to the available clearance under the beam, without increased height of the poles because of the feeder system for which the poles necessarily are designed. Ordinarily, the bridges are set 300 ft. apart on tangents, the spacing being reduced on curves in the usual manner. The contact wire is number 3/0 grooved phono-electric carried 24 ft. above the rail tops, with a maximum horizontal variation of 12 in. at the center of the track both ways, due allowance being made for the super-elevation.

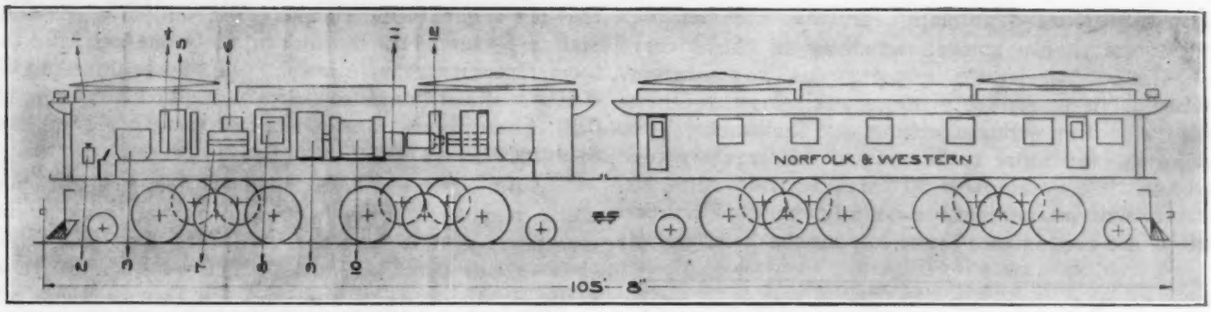
The overhead construction is exceedingly simple. On tangents a steel casting attached to the horizontal beam, supports three suspension type insulators, any one of which is good for the working voltage of the line. From the bottom of the lower element a malleable iron casting is suspended that clamps to the messenger wire. The latter is a ½-in. extra high tension galvanized steel cable, and from it at 30 ft. intervals the hanger straps are suspended, from the lower ends of which are hung the auxiliary messenger wire, which is number nought round copper on steel. The contact wire is clipped to the messenger wire at 15 ft. intervals, so spaced that they are equally distant from the hangers that support the auxiliary messenger wire; a construction that altogether makes for a very flexible and smooth running contact.

The temperature variations on this line are severe, in consequence of which the structure is stressed, at times, up to the elastic limit. The liberal use of steady strains on long tangents keeps the contact system in line. On curves, (it should be remembered that 60 per cent of the line is curves), the trolley wire is held within the horizontal limits above specified, by shifting the clamps along the beam. On sharp curves the use of pull-out poles designed with auxiliary messengers produces an effect well known to those familiar with a similar construction on the Oakland, Alameda and Berkeley lines.

In the long tunnel, special construction was necessary because of the steam and smoke emitted by those steam locomotives that are still used for economic reasons on trains running over the branch lines. The contact wires are supported every 75 ft. from 44,000 volt insulators on which are secured a cross pipe bent to follow the arch of the tunnel and from which the bronze messenger wires are supported. The construction is such that two 44,000-volt insulators are in series between the contact wire and the walls of the tunnel. On the branches and coal mine sidings, comparatively inexpensive wood pole bracket type construction is used.

The track bonding is unique in that a special construction permits a concealed type of bond to be installed with the removal of only one bolt per joint. The bond terminals are expanded in holes in the rail by means of the well known steel drift pin. One terminal is welded to one end of the bond, the free end being tinned to permit pushing the bond through under the angle bar and to facilitate soldering after the bond is so installed. Both terminals are then placed in the holes in the web, and drift pins driven.

Track transformers located at approximately one-mile intervals are installed to reduce inductive interference with the telephone and telegraph circuits. Personal tests on the different dispatching business circuits showed that these inductive troubles produce less effect than in the case of most long-distance transmission power company circuits of which I have any knowledge. Experience on this line shows that interference under ordinary working conditions can be reduced to the negligible point. With a short circuit on the transmission or contact system, however, the results are as heretofore—namely, a practical paralysis of the telephone systems for the time being. Experience here indicates that probably the best results can be obtained in such installations by a short distance between feeding points and by feeding both ways, avoiding stub and feeds. That these disturbances are of little practical moment is demonstrated in the exclusive use of the telephone for train dispatch-



The Complete Electric Locomotive with Same Apparatus in Both Halves

ing purposes. Furthermore, the company maintains a private telephone system for the transaction of business over its entire line.

Locomotives.—The locomotives have been described so many times in the technical press that a detailed description here is hardly warranted. Furthermore, we are more concerned at present with the performance of these machines than with the details of their construction. It is well, however, to note some unusual features of their construction.

Each unit consists of two parts, practically identical. For convenience, the two halves will be considered separately. They have two main trucks connected by Mallet hinges, each truck being provided with two driving and one guiding axles. The trucks are then placed back to back so that the classification is 2-4-4-2. The driving wheels are 62 in. in diameter, and the guiding wheels are 30 in. The total weight on drivers is 220,000 lb., and the total weight of the unit, 270,000 lb. The length over all of the two units coupled together is 105 ft. 8 in. The rigid wheel-base is 11 ft., and the total wheel-base, 83 ft. 10 in. The driving motors, of which four are mounted in each unit, are 3-phase, adjustable speed type. The maximum accelerating tractive effort of the locomotive (two units) is 125,000 lb.; the one-hour tractive effort, 87,000, and the continuous, 68,000 lb.

The operating conditions on this line are in many respects closely similar to those on the Sierra Nevada and Tehachapi grades, where, owing to the length of the train and the difficulty in signaling from one end of the train to the other when the pusher is used, it is not at all unusual for it to stand at full tractive effort for a minute or more before the road engine has pulled out enough slack so that the pusher can move. Conversely, when a train is coming to a stop on an adverse grade, the road engine shuts off and applies the brakes, while the pusher keeps moving until the bunching of the cars ahead of it brings it to a standstill. The result of these motor characteristics is an extremely easy, smooth handling of the train under such very severe conditions.

The liquid rheostats permit an adjustment of the load of the individual motors, so that the engineman, by watching his ammeters, can develop the maximum tractive effort of the machine without danger of burn-out of any part of the equipment. This sort of control is a very great advantage in handling a train on a heavy grade with bad rail, it being possible, under these conditions, to load all motors right up to the slipping point, regardless of variation in diameter of driving wheels or of the condition of the particular piece of track on which the unit may be standing momentarily.

The maintenance of these machines in road service conditions is taken care of at the inspection shop at the east end of the line. Once a day they go over the pit, where the usual mechanical adjustments are made, that is, taking up the slack in the brake rigging, inspection of contactors, etc., up to, but not including, dropping out of the wheels, for which they go once a week to the general shop. Not more than 40 minutes are allowed at the inspection pit. The cabs are interchangeable, so that in case of trouble the maximum number of units can be kept on the track.

The machines average about 80 miles a day, which means practically two round trips across the electric zone, plus switching as may be required. These two trips constitute a day's work for the crew. Up to the time of my visit, with the exception of some locomotives damaged in collision, none of the machines had been into the general shop for more serious work than relining of wedges, dropping of wheels,—which normally keeps the machine out of service about one week.

The force at the inspection pit consists of one inspector, one machinist, one wire-man, one oiler, and two laborers.

The ease of control of a train with these machines is simply amazing; one of the principal difficulties a man has in operating on this district is to keep awake. The constant speed, both up hill and down, the droning sound from the motors, and the absence of apparatus that demands constant attention, all combine to put the most active man into a somnolent condition; as a matter of fact, two trains got together one night simply because one man was sound asleep and the other man was unable to back his train uphill, out of the way. After the train is once in motion, there is nothing to do but to watch for signals.

Much public notice has been taken of the regenerative control, which is handled about as follows: As the engine passes the summit, the engineman watches the ammeter, and when the current begins to drop, he shuts off at the controller and throws the regenerating switch; then opens the controller to running position. In a few seconds the current builds up to three or four hundred amperes and the train is at synchronous speed, plus the slip; in other words, the train travels uphill at synchronous speed minus the slip, and down hill, at synchronous speed plus the slip. It is difficult for one accustomed to the necessarily rough handling of long freight trains on steep grades, to

refrain from extravagant language when commenting on the remarkably smooth handling of these very heavy trains by electric motors plus regenerative braking. The starts are made as easily as the O. A. & B. trains and without jerking out the slack. The braking is even more to be praised. It was my observation that even up to 90 cars the train came to its stops without perceptible jar anywhere. Furthermore, while setting out empties from the head end it

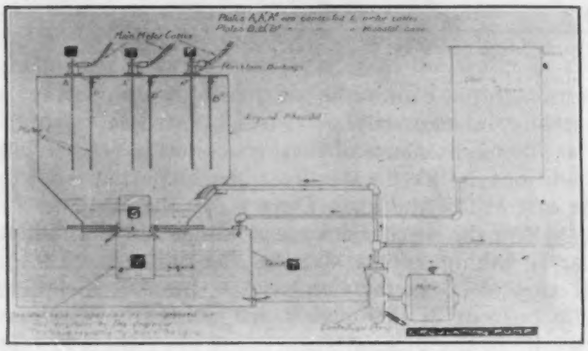


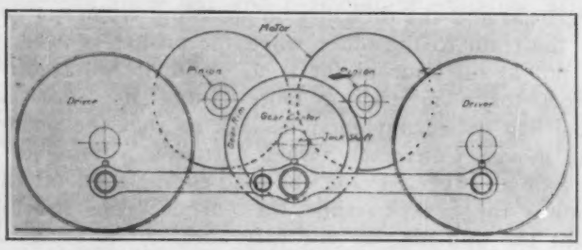
Diagram of Water Rheostat for Regenerative Equipment

was impossible for me to determine without looking back, whether the engine was working light, or with only a few cars, or was starting the whole train. When regenerating on the heaviest grades, if for any reason the air has to be used, the orders are to brake to the bottom of the grade by air alone. The reason is that a considerable time interval is required to change the phase converter connections after synchronous speed is reached, and they fear losing control of the train in this interval, because acceleration on these grades is so rapid that in a few seconds the train would reach a speed high enough to cause the wheels to slide back to synchronous speed, at which point regenerative braking is impossible. In the early days of electric operations, attempts were made to brake jointly by air and motor, but there resulted very heavy shocks to the train and practice had to be abandoned. My notes record that on one of the trips the current regenerated on the heavy grade on the east side of the Elkhorn tunnel was just about the same as that taken by the motors in pulling up the west side of the same grade, which means, of course, that a train going down the east side would very nearly supply the total power needed to pull a corresponding train up the west side; the difference being due to the double losses in the two sets of transformation. Current readings do not give any measure of the actual power taken or returned, for the reason that the power factor varies; for example, I have notes that, with the motor pulling the train down a slight grade, practically the same current was taken as when regenerating on the heaviest grades. My notes give 6300 k.v.a. and upward regenerated during the first part of the heaviest grades after leaving the tunnel, which dropped off quickly to 1600 and down as low as 800 as the train speed was reduced. Probably not more than 25 per cent of the regenerated energy gets back to the power house. This is indicated by the fact that the graphic charts at the station show very few drops below the zero line, which means, of course, that the regenerating rheostats are seldom used. The station power factor is approximately one-half, and the local factors are as follows: On the 5-minute basis, 0.3; on the 15-minute, 0.35, and on the 60-minute, 0.5. These figures are considered merely a good, fair average.

With eight locomotives in service, probably not more than three trains would be on the track, under maximum conditions; the power house loads then show about 6000 kilowatts per train on the grade, going up to between nine and ten thousand for one minute, while accelerating; and the average over the whole line is approximately 4000 kilowatts.

Some criticism of the constant speed feature of operation has been made by steam railroad men who are not conversant with the results thereof. The train dispatchers speak most enthusiastically of this feature, which permits them to count on the arrival of a train at a given point within a fraction of a minute; consequently, their dispatching is rendered very much easier. As a result, any freight train is sent out on the line ahead of any passenger train whose schedule speed is not more than 15 miles per hour, and the passenger train is not held up. I came in on a very heavy eastbound train that actually was sent out on the line 20 minutes ahead of a passenger train, and we pulled into the Bluefield terminal in plenty of time to clear the passenger train. Such operating would be unheard of on the ordinary steam line.

The results of electric operation are most satisfactory. The general superintendent informed me that the largest saving was due to better handling of the traffic, in that lost motion is eliminated, no stops for fuel or water and to blow up steam, are necessary; therefore, the trainmen have less grounds for excuses for delays; hence there is a general tuning up of all hands. Under steam operation it was very difficult to realize more than 7 miles per hour schedule speed, while under electric operation they can count on 14, and, quite as important, they can count on handling full tonnage without loss of train speed. Last May, trouble in the power house cut down the electric loco-



Arrangement of Motor Jack Shaft and Driving Wheels on One Truck

motives available from six to two in service, of which only one could be used at a time, on the hill. As a result, 16 of the largest type Mallet steam engines had to be brought in from other divisions in order to maintain the traffic.

At the time of the inauguration of the electric operation 18 Mallets were assigned to the hill. These were rated at 1050 tons trailing load at 8 miles per hour; but the maximum that could be gotten out of them at 14 miles per hour was only 800 tons. Two

Mallets plus a pusher on the heaviest grades hauled the 3250 ton train, and the load from Flat Top in, using the two road engines, could be not greater than 4000 tons. All Mallets are now assigned to other divisions. On the basis of their former performance, the present traffic would require 24 Mallets, a traffic that is now handled easily by eight electrics, with occasionally one more; and the entire electrical equipment of the line consists of 12 locomotives.

As was stated previously, the result of all these improvements is a practical doubling of the capacity of the line over what it was under steam conditions, which in itself is a sufficient warrant for the expenditure of the four million dollars the electrification cost. It is significant, however, that the general manager of the line refused to give me any operating costs per ton-mile, because, as he said, such figures as were available would not be fair to electric operation.

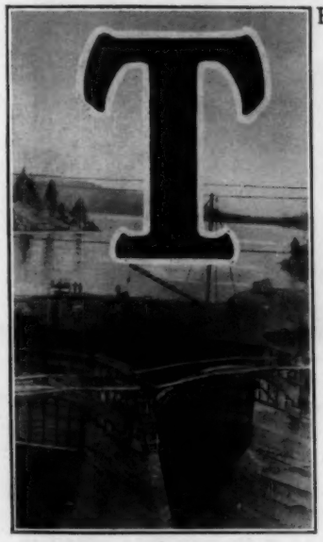
Since the opening of traffic the trolley wire has been burned off once, due to inexperience under sleet conditions; two enginemen have been killed—both went on top of the locomotive cabs contrary to orders, and absentmindedly put themselves in contact with the trolley wire.

It is interesting to note that extensions that will materially increase the electrified track mileage of the electric zone are now planned. No new district will be electrified, but the present zone will be enlarged, by extending the electrification, westward, and by taking in some branches. The purpose is to get away from a certain amount of forward and backward train movement and to derive other substantial benefits that will come from a more complete electrification of this zone. No additional locomotives have been ordered to provide for the increased mileage of electrified track.

THE MULTIPLE-ARCHED vs. THE SINGLE-ARCHED DAM

BY JOHN S. EASTWOOD

(Sober consideration of the factors that enter into dam design since the great floods of 1916 and their consequent disaster is timely at this moment, when many additional projects of mammoth proportions are under consideration. The columns of the Journal are always open to proponents of various types of dam design, since only by consideration of all the factors that enter into an engineering problem can we hope ultimately to reach the goal of perfection in design. Nowhere in the world has dam design been carried to a higher pinnacle of success than here in our Western country, where men dare and make good in their efforts. The autthor of this article is the originator of the well-known type of dam known as the Eastwood multiple arch and as a consequence this comparative discussion is of unusual interest.—The Editor.)



A Multiple-Arched Dam Replacing One of Single-Arched Design.

THE Rankine Ring Formula has been used by most of the engineers who have designed and built arched dams, as the rule for the computation of the stresses set up in them. This formula has been used by some of them as though it were a universal formula that was applicable to all cases and by others it has been used as if it had little influence, and curvature has been introduced into the design of dams as though it had no influence on the stresses set up in them.

Some of them use it as the only factor in setting up stresses while others use it as though it did not particularly affect the stresses in the structure.

This formula is expressed as $T = pr$, in which expression **T**, is the tangential thrust set up by water pressure on a curved surface, **p** is the water pressure per unit of area, **r** is the radius of the curve of the surface pressed. If **q** is the allowable loading on a unit of area of the material of the arch ring and **t** is the required thickness to resist this pressure, $\frac{pr}{q} = t$.

This formula is applicable only when the conditions of loading are as expressed by its author, that of a case where a semi-cylinder of a linear arch under hydrostatic pressure supported by the other half equally loaded. The formula is then only strictly applicable to the above particular set of conditions and any departure from these conditions will cause a like departure of the applicability of the formula. The degree of departure from the stated conditions will influence the degree of the accuracy of the results obtained. Its universal application to all conditions will lead us far from the true results.

To illustrate its application by means of a series of arithmetical examples, we will assume to have been eliminated as many of the conditions as possible that limit its application; also, we will take the dimensions of our opening sufficiently large to accentuate the departure of the indicated results from the actual.

Let us assume an opening having a depth of 200 feet and a width of span of 1000 feet. This opening we will assume to be closed by means of a single-arched dam, free to move on a frictionless base and having hinges or voussoirs to remove the reactions due to rib shortening reactions. To this ideal dam let us apply the Rankine ring formula to determine its stresses and required base thickness, considering the bottom ring of one foot depth, the center of which is 200 feet below the surface of the water.

The water pressure on a unit of area, 1 square foot, or **p**, will be 6.25 tons; assume **q**, the safe loading as 300 lb. per sq. in. or 21.6 tons per sq. ft. in compression, and introducing varying radii, to ascertain the required base thickness of the arch ring.

Example 1. Angle of arc, 180°, giving radius of extrados of 500 feet. 500 × 6.25 = 3125 tons, tangential thrust, T, which divided by 21.6 = t, the thickness required, or 144.68 feet.

Example 2. Angle of arc, 90°, radius, 707.1 ft. thrust 4419.4 tons, required thickness 204.6 ft.

Example 3. Angle of arc, 45°, radius, 1306-6 ft. thrust 8166.2 tons, thickness 378.1 ft.

Example 4. Angle of arc, 1°, radius 57296.0, thrust 358200.0 tons, thickness required, 1658.3 ft. or 12.67 times as thick as would be required for a straight gravity dam of same height.

The straight gravity section 200 feet high will require a base width of 130.93 feet. (see Weggman, plate XLLL).

Example 5. Angle of arc, 180°, for equal thickness of base, the limit of span will be 904 feet, for angle of arc of 133° 34′ were used, for equal thickness the span limit will be 831.0 feet. If an equal quantity of material were used, and economic arc of 133° 34′, used, the span limit will be 655 feet, in which case the stress in the single-arched dam would be 21.6 tons per square foot as against 17.8 tons in the gravity section. If we take equal stresses in each type, and the same arc of 133° 34′, the span limit will then be 539 feet for 17.8 tons.

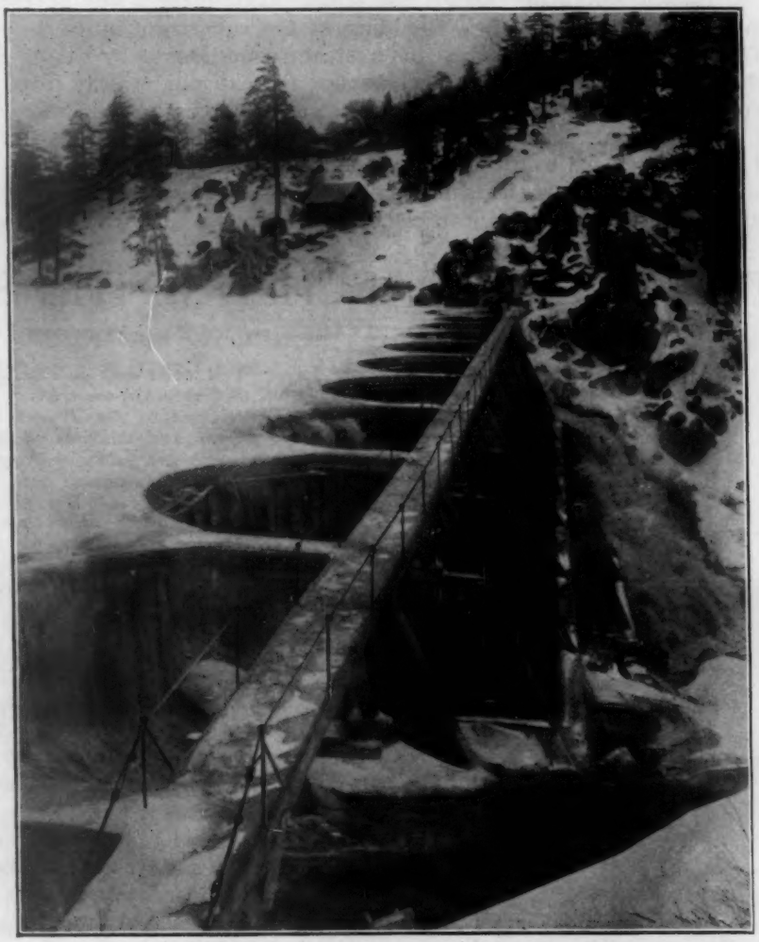
If the Rankine ring formula is correct for all conditions, as the use of it by all of the engineers that have built single-arched dams would indicate, this type of dam to compete with the straight gravity dam, will only be economical for very narrow spans. Manifestly it is not true except when used in the sphere for which it was derived by its author, otherwise, some long radius dams would be taking more stress than if designed as straight gravity dams. Its departure from the truth as a means of arriving at the true stresses will depend on the departure of the conditions met in practice from those upon which the formula is based.

But the ideal conditions above mentioned do not exist in any natural opening, for here we have sloping sides, preventing the use of hinge joints, the base of the structure more or less rigidly attached to the foundations and sides, a constantly varying angle of arc and thickness of arch ring, a constantly varying consistency of abutments and foundations, a constantly varying upthrust under the foundations, and all of these singly or combined to vary the stresses in all parts of a single-arched dam.

As all of the so-called constant angle arched dams and all of the single-arched dams built by L. A. B. Wade in Australia were designed on this formula, it would appear that the departure from the exact truth as to the stresses claimed to be in them, will be quite marked. Many other curved dams have been built with long radii, and if they were stressed in proportion to the results to be obtained by the sole use of this formula, some of them would appear to be quite heavily stressed.

However, the ring formula does not apply, except as to the case of ascertaining a part of the stresses to be met in a single-arched dam, but what the stresses really are and how far this formula applies, is a different and longer story, not to be taken up in this article.

What is true and of importance here is that the use of curvature in a gravity section dam of great length is rarely ever considered in any other light than the general idea that the curvature will add to its safety. There are many curved dams now built that would be better dams if they had been built as straight crest gravity dams of equal quantity.



The New Big Bear Valley Dam Withstanding Heavy Flood of 1916

It is only well within the span limits assumed in the typical case above mentioned that the single-arched dam commences to show an advantage in quantities and equal safety over a straight crested gravity dam.

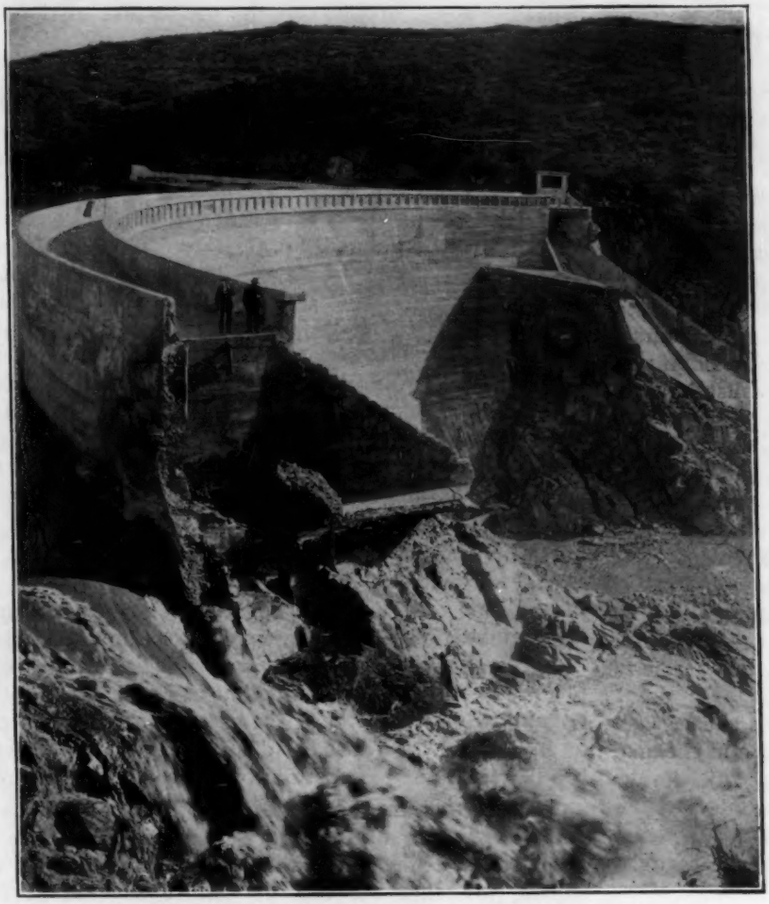
The constant angle of arc for minimum quantity, is difficult to apply in practice except in the case of an ideal site, and for such a modified multiple-arched dam will always be stronger and cheaper.

The bending reactions at the abutments of the thick sections of single-arched dams have not been given due consideration, for if the abutments are of material fit for abutments, these will be very large; and if of soft and yielding material, as is sometimes

the case, they are not abutments at all and the dam does not act as an arch.

Rock that is shattered and that can be washed out by water will not constitute an abutment to take a horizontal loading.

The single-arched dam is not readily adapted for use as an overflow dam, for if it is thin enough to warrant its use over a gravity section dam, it will have almost vertical back slopes.



The Well-Known Sweetwater Dam With Abutments Being Destroyed in Heavy Flood of 1916

(An Example of the Difficulty of Getting Abutments at the Sides of a Canyon Sufficiently Firm to Resist Arch Action)

The comparative thinness of section of a single-arched dam of large span is its only chance for economy over a straight gravity dam and this thinness of section is its most dangerous feature.

In order to demonstrate this statement, we must consider the limitations of the materials we can use for dam construction. Portland cement concrete has become considered as almost a synonym for masonry, when discussing dams.

Concrete is subject to two causes of change in volume that are both in the same direction; swelling with increase of heat and moisture content and shrinking with the loss of these.

In practice, dams are built in the summer when it is warm and the concrete will not freeze. The concrete in setting generates an additional amount of heat, sometimes reaching 150° F. for large masses, such as are here considered; also, it is placed wet and will retain at least a normal saturation. The temperature will drop permanently to the mean normal for the location, the moisture content will also decrease to a degree, permanently at the top of the dam. The volume change is in proportion to the unit length of the wall and will be through a greater range in a thin wall than in a thick one.

A single-arched dam, having the economic arc of 133° 34′, will be 1.27 times as long as a gravity dam for the same site, and the stresses set up by the volume change are so much greater due to this length; and they are also more by reason of the fact that the gravity dam will be much thicker and subject to a smaller range of change.

The range of change will be directly proportional to the stone element in the material of the dam as this is not subject to any moisture change and only a slight temperature change.

If the single-arched dam is used as a diversion dam and is always wet it will not be subjected to great changes of moisture content and the temperature drop is likely to be offset by the excess due to complete saturation, so that such dams will not crack to any dangerous extent. It is where the service is for water storage that the worst conditions prevail, where they are now full and then empty.

In locations where the range of temperature is large and for a service where the reservoir is held empty for a good part of the time, the single-arched dam will be subjected to the greatest stresses.

The fact that the base of a single-arched dam is attached to the foundations may be an apparent advantage but in practice is its worst feature, for, while it would assist in the stability of the structure were it possible for it to act as a whole, it merely prevents arch action of the separated voussoirs and introduces as the only stress the cantilever action tending to overturn them.

The economy in material of the single-arched dam will limit it to short spans, and if it is to show a great saving over a gravity dam it must do so by its reduction in thickness as it is longer, this again accentuating the dangers of cracking.

In any case of a large or even moderate span, it is impossible to reinforce the walls of the single-arched dam sufficiently to prevent cracks. The only alternative is to provide artificial joints that can open up to prevent natural cracks that might occur diagonally across the wall, permitting a voussoir to fall out down stream.

As these artificial joints must be placed fairly close together to prevent intermediate ones forming, the unstable separate voussoirs will be in danger of breaking off at the bottom.

As an example in illustration of this point, the

Lake Spaulding dam was provided with artificial joints at each 80 feet of crest length, but the stresses set up by the agencies above mentioned, caused other natural cracks between each of these joints.

All of the Australian single-arched dams have cracked vertically and some of them along the step lines where stepped on the downstream side, as reported to the writer by the contractor who built them.

The Salmon Creek dam has cracked at the crown and has a permanent open natural crack from top to bottom through which quite a large stream of water flows, according to a recent visitor to this structure.

The combined permanent shrinkage will open up cracks in artificial joints or make natural ones if joints are not provided, and with joints forming open cracks, with the base rigidly fastened to the foundations, there can be no arch action whatever. When the reservoir is full, there will be cantilever action and such only, unless the blocks of which it must consist are sheared off or are broken by tension and take arch action by sliding into a new position where they can so act.

If all should move at once, all would be well, but in practice all are not similarly fastened to the foundations. If the section is thin enough to be economical, it will be too thin for a cantilever and must be ruptured.

There is less danger of cracking and less danger from these in a gravity dam with straight crest for the walls are thicker, which will reduce the range of change and are shorter which will reduce the units of length. There is less danger for the gravity dam if cut into thin slices, as each slice would be equally stable. The volume change is directly in proportion to the unit length, and also will vary inversely with the thickness, so the cracks will be smaller, and if made by artificial joints, are harmless as well.

It will then appear that experience has shown that the straight gravity dam will be both safer and cheaper for wide openings, that the single-arched dam should be confined to very narrow and deep openings where the abutments are sound, which would lead to the conclusion that its field of usefulness was exceedingly limited.

Such very narrow and very deep openings are most economically closed by means of a single-arched dam having a minimum radius of intrados or a constant angle of intrados of 180°, as suggested for the Shoshone site.

Even so, there is no opening that cannot be more efficiently closed by a modified multiple-arched dam.

The conclusion of the whole matter is that to be efficient, by which is meant to be free from technical objections and economical as well, the arch when used, must be used as such, and as free from all of the limitations as possible.

The arch, to be efficient, must take its loading as an arch, and to be an arch, must approach as nearly as possible the ideal conditions for the arch action determined by the ring formula. It must be as thin as is practicable, it must have as short a radius and span as possible, it must not be confined and subjected to base shear or contilever action, must be provided with a uniform span so that it may be hinged where it is required to be thick to take its load, and must be thin enough to be protected readily from the small volume change stresses due to small dimensions, by steel reinforcement, and the only way that all of these conditions can be met is to place the arches on closely spaced artificial abutments, in other words the dam must be multiple-arched.

The multiple-arched dam, consisting of a number of relatively thin and small cylindrical arches, supported by artificial abutments, spaced a uniform distance apart, suggests itself as the logical and scientific solution of the problem of the proper use of the arch for a dam.

In this type of structure, all of the features that are objectionable in the single-arched dam and which are the result of its size and shape, are eliminated by the changes in size and shapes of units introduced in the multiple-arched type.

The span can be made of any desired width to be the most economical for the site. The angle of arc and radius can be made the most efficient. The sloping of the arches down stream in order to utilize the water load to assist in giving it stability removes the danger of base shear, as the thrust is toward the foundations. The great length of arch barrel compared to span, removes all cantilever action. Its comparative thinness makes it the nearest approach possible to a pure arch tangentially stressed in conformity with the ring formula, and for resisting water pressure there is no better shape possible.

The arch walls are thin and therefore there is no heat generated by the setting above that of the air at the time of setting. Being thin it has but a small temperature drop from the time of setting to the time of service. Being thin, the arch ring is readily reinforced for the small changes that can take place. The opening to be closed has parallel sides so the arch can be hinged where desired and necessary. The stresses can be maintained almost uniform throughout the arch.

Of all the stresses set up in both the straight and curved types of solid masonry dams, there is none of them so ill defined and uncertain in amount and resulting influence for causing failure as that of the upthrust of the water confined under or in them, resulting from porous foundations or days work joints, for this may run all the way from full to only a small amount.

It is this upthrust acting in conjunction with the regular water load, both tending to slide and overturn the dam, that has been the cause of the failure of most all of the solid dams that have failed.

In the multiple-arched dam, upthrust is cut out of the problem, for there can be none, the water being free to escape between the relatively thin walls of the arch toe and the buttresses.

It cannot overturn, for the structure is provided with balanced stability, the base load being evenly distributed.

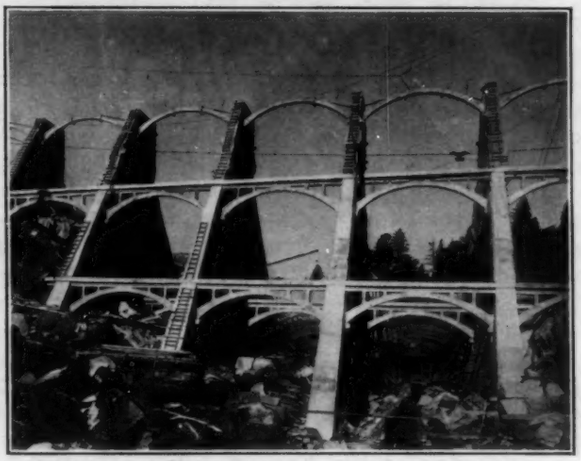
It cannot slide on its foundations for it has a base shear strength having a safety factor of 15, besides having the friction resistance of the load.

All of the loading is downward on the foundations and this loading is light.

All of the stresses are determinable to a marked degree of accuracy, so that they can be provided for in the design.

All of the stresses are in compression, the best service for concrete, and this is given a safety factor of 10.

All stresses are kept nearly equal and it is therefore the scientific design.

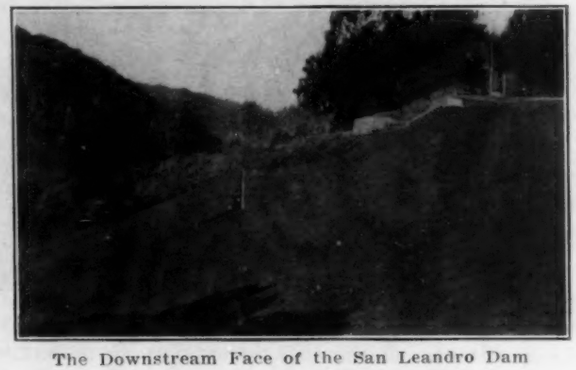


The Multiple-Arched Dam Under Construction

With all of the advantages of the solid types and none of their disadvantages, with their most dangerous elements eliminated, with a strength five times as great, with equal permanency and watertightness, and all this at a cost of half that of the other types, the multiple-arched dam points out in its results the true path to follow in order to reach the goal of perfection in design.

THE DOWNSTREAM FACE OF THE SAN LEANDRO DAM

This picture, taken recently, shows the downstream face of the San Leandro Dam of the Peoples Water Company, near Oakland, California. This dam, constituting as it does a remarkable achievement in dam construction, due to its being one of the first high



The Downstream Face of the San Leandro Dam

dirt dams successfully constructed in the West, presents at the present time an unusually satisfactory showing on its downstream side in solidity and firmness of structure. In the picture the drains and general surface condition are shown which clearly indicate this favorable feature in design of dams of this type.

OZONE FOR THE CHILDREN—III. OR ENGINEERING TWISTERS RETOLD

A quiet little fellow, evidently an automobile enthusiast, but hitherto unnoticed, now injected himself into the conversation by describing a problem he had encountered in following up tire troubles in operating his automobile for the agricultural power sales department of a prominent hydroelectric company. Thus he proceeded:

My auto is twice as old as my tires were when my auto was as old as my tires are. When my tires become as old as the auto is now, their sum will be 9 years. What is the age of my auto and of my tires?

Let x = auto's age.

Let a = difference between auto and tires.

Then $x - a$ = tires age.

Auto was $(x - a)$ when tires were $(x - a - a)$

$\therefore x = 2(x - 2a)$.

$x = 4a$.

Auto will be $x + a$ when tires are $(x - a + a)$.

$\therefore 2x + a = 9$.

$2(4a) + a = 9$.

$a = 1$.

$x = 4$ yrs. (auto.)

$x - a = 3$ yrs. (tires.)

THIRTY THOUSAND FIRES FROM CARELESS USE OF ELECTRIC APPLIANCES

A new form of fire peril is coming into prominence as a cause of much destruction, and its fires are so directly associated with carelessness that it has been deemed necessary to issue a special warning to the people of the United States. Because of their convenience, small electric devices, such as pressing irons, curling irons, toasters, electric pads or blankets, electric plate warmers, and electric sterilizers or heaters are now to be found in almost every community. If these were used with proper care the danger would be negligible, but, unfortunately, a proportion of their users does not realize the peril of leaving them in circuit when not in use. In such cases these devices tend to become overheated, whereupon they are likely to set fire to anything combustible with which they are in contact.

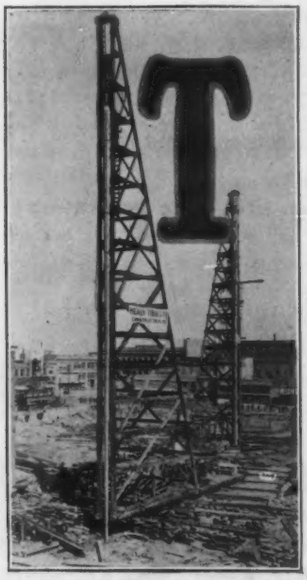
Fires of this class furnish a special peril to life, being most frequent in dwellings and often breaking out at night. A characteristic example is that in which an electric pressing iron is left upon the ironing board, with the current turned on, and then forgotten. In such a case the fire may not occur until some hours later. The burning of the residence of John Wanamaker, several years ago, was due to an electric pressing iron.

That this form of hazard is already assuming large proportions appears from the statistics. For example, Actuarial Bureau of the National Board of Fire Underwriters in one day noted approximately one hundred reports of fires from this cause, out of a total of two thousand losses in the day's reports, and it estimates that small electrical devices are causing fires at the rate of 30,000 or more in the course of a year.

A NEW RECORD FOR FOUNDATION PILING

BY JOS. M. McCOY

(Fifty miles of piling is an astonishing figure to mention in connection with the creation of foundation footing for an office building, and yet this is the combined length of piles recently driven for the great Southern Pacific building now being erected at the foot of Market street, in San Francisco. Many unusual engineering feats encountered and overcome in the work are described in this article, the author of which was superintendent for the construction company which performed the task.—The Editor.)



A Giant Pile Driver for Piles 130 ft. in Length

THE work, just now completed, of creating a foundation for the new Southern Pacific General Office Building on lower Market Street in San Francisco has attracted considerable attention locally and a brief description of the job will undoubtedly prove of interest. The subground required to furnish foundation to the finished building, a modern steel frame structure of ten and fourteen stories and approximately 275 ft. by 210 ft. in plan, consisted of a surface crust of various filling overlying the original bay bottom strata of mud and other soft sedimentary deposits with harder bottom at an uncertain depth which presented unusual features as the driving of the piles progressed. As a preliminary test of foundation conditions, four timber sounding piles 130 ft. in length were driven to actual refusal with their points on hard material at approximately 130 ft. below the street curb; the level of the hard stratum being verified by the sinking of a well hole. Two of these test piles were loaded with pig iron equal in weight to at least twice the ultimate foundation load to be carried by any pile, making a satisfactory test. Accordingly pile clusters were chosen as the support for the steel column footings of the building, the piles to be of the best Douglas fir obtainable and not less than 115 feet in length, the average cut off for piles according to the foundation plans being 15 ft. below the street curb and thus several feet below the permanent water table for this locality.

As a preliminary to pile driving, the basement section was excavated by a steam shovel loading into motor trucks with back-dump bodies. The excavator was an 18-ton revolving shovel with ¾ cu. yd. dipper, and eight or more 5 yard trucks gave excellent satisfaction. Some water and many obstacles were encountered, but the steam shovel, aided by compressed air drills and more than 1200 pounds of 40 per cent dynamite exploded within a few feet of the city's busiest thoroughfare, was equal to every task imposed. In addition to loading out approximately 20,000 cu. yds. of debris fill, sand and blue mud and clay, the shovel with jack hammers and explosive crumbled 2000 cu. yds. of reinforced concrete and masonry foundations. Hundreds of old piles were encountered, necessitating sawing, chopping or pulling with the shovel; timber structures with teredo eaten piles indicating old wharves, were uncovered and removed; and much large timber and "scow" building foundations, consisting of many ply of interlaced redwood, were dug out. All timber encountered below minus ten feet from curb was in an excellent state of preservation. Several pumping units kept down the water during the digging, and by the generous use of heavy planking the steam shovel and motor trucks were held up in the soft material.

But the greatest interest in this as a foundation job probably centers in the handling and driving of the piling, due to the great size and length of the piles and the strength and height of the machines necessary to drive them. The somewhat over 2100 long piles under the main building were obtained from the Douglas fir forests of Oregon and transported overland by Southern Pacific railway lines (about 15 piles being loaded on each three flat cars) to the Oakland Estuary. Towed across the bay in rafts, the piles were hoisted from the water on the San Francisco side by a floating derrick and hauled to the site of the work butt end on trucks pulled by six horse teams. A teamster piloting his 200 ft. long "caravan" through city streets had troubles of his own.

The average pile had a butt diameter of 20 inches, tip diameter of 10 inches, and weighed 5 tons. Some

The Foundation Setting for the Largest Steel Structure West of Chicago

of the larger sticks ran butt 30 inches, tip 16 inches, and weight 7 tons. A considerable number of piles over 130 ft. in length were handled and driven, the longest pile being 137 ft. There is one long pile for approximately every 22 sq. ft. of foundation area under the main building, giving a pile occupied area of about 10 per cent and a pile occupied volume of from 7 per

cent to 8 per cent. The pile volume would be equivalent to a ground raise of 9 ft. over the area piled. Of course not all the displacement of the piles was felt in the raise of the ground during driving, the compacting of the sub-ground and the driving out of water taking care of a considerable amount. To express again, however, the quantity of timber (in piling) put into the foundation, it would approximate 16,000 cu. yds. or 5,400,000 ft. board measure. Or again, the piles placed end to end would reach 50 miles.

The two main pile drivers used were built especially for the job; the sills being 60 ft. long, height 135 ft., and strength and weight in accord with the heavy work to be performed. The heavier machine of the two weighed 85 tons, contained 30,000 ft. board measure of pine and Australian iron bark timber, and 5 tons of bolts and hardware, and was equipped with a steam hammer weighing 16,000 pounds. The towers for both pile-drivers were framed and assembled complete on the ground and then raised to the vertical position by the donkey engine on the stern of the driver operating through heavy rigging. Both towers were raised and lowered without a mishap; the amount of the forces operating, however can be gained from the fact that the weight of a tower (with temporary bracing, and rigged for raising) was 45 tons and the height 135 ft.

Pile driving records would indicate that the solidity and permanence of the pile foundation secured for the building is unquestionable and that all piles will bear safely far more weight than any foundation load to be imposed.

G. B. Herington, engineer in charge for Assistant Chief Engineer J. Q. Barlow, has been in charge of the work for the Southern Pacific Company. The contractors performing the excavating and pile driving work were Healy-Tibbitts Contruction Company of San Francisco.

PRESERVATION OF POLES

One of the most important factors in determining the value of a pole is its ability to resist decay in contact with the soil. While durable woods are generally preferred as pole timbers, there is a tendency toward purchasing other species which are not as durable, but which can be rendered less liable to decay by preservative treatment.

In the treatment of poles several methods are used. Among these are the brush treatment, the open-tank treatment, in which the poles are stood on end in open tanks or vats containing the preservatives; and the pressure treatment, in which the poles are placed in cylinders into which the preservative is then run and pressure applied to force it into the poles. Much progress is being made in the butt treatment of cedar poles by the open-tank method, which is being used extensively in Idaho, Washington, and California, and in the Minneapolis and Chicago districts. A considerable proportion of the cedar poles sold receive a butt treatment.

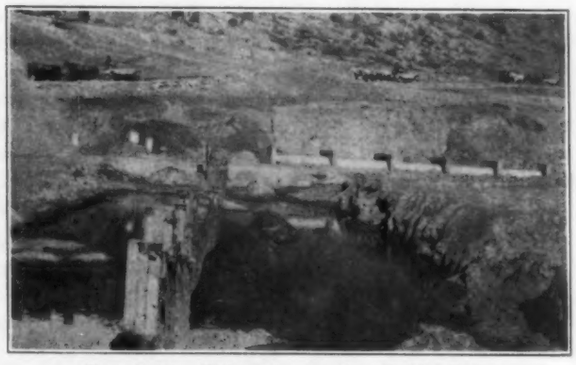
THE BEGINNINGS OF THE NEW SAN PABLO DAM

The San Pablo dam, construction upon which was initiated about six months ago, is located in the San Pablo Valley about five miles north of Berkeley, and five miles east of the city of Richmond.

Since the matter of the building of this dam is now a very live topic before the California Railroad Commission, its general proportions will be of unusual interest to our readers. The work is being carried through by the East Bay Water Company which supplies water to the cities on the eastern side of San Francisco Bay.

The Location of the San Pablo Dam

This project involves the construction of an earth dam 165 ft. in height, having a crest length of approximately 1375 ft., a waste tunnel 14½ ft. inside diameter and 1,350 ft. long, an outlet tunnel 7 ft. by 9 ft. in cross section and approximately 15,000 ft. long, together with a modern filter plant and all necessary appurtenances in connection therewith. The reservoir when complete will have a capacity of approximately 1,900,000,000 cu. ft. The project will require a period of approximately three years for its completion.



Foundation Piling Across San Pablo Gorge

William Mulholland is the consulting engineer, G. H. Wilhelm is the acting manager of the company, and A. Kempkey is the engineer in charge of the project.

The dam foundation has been cleared and bedrock exposed, as shown in the illustration. The piling that appears in the central view has been driven across the narrow aperture of the canyon in order to make an impervious medium to prevent future seepage through the foundation stratum.

SHORT JOURNEYS IN PACIFIC LANDS

(A discussion of the traits and customs of our Latin American neighbors with especial view toward creating closer engineering and commercial relations with them, is especially opportune at this time. Here is an article by an American engineer who recently spent two years on the West Coast of South America during which time he was actively engaged as operating engineer of a prominent hydroelectric system in Peru. The author is now with the engineering force of the Pacific Tank & Pipe Company in San Francisco.—The Editor.)

ENGINEERING OBSERVATIONS ON THE WEST COAST OF SOUTH AMERICA

BY RALPH W. REYNOLDS

An Ancient Peruvian Engineering Accomplishment—a Stone Neck-breaker. After Passing the Head of the Victim Through the Opening, the Body was Thrown up Over and the Neck Thus Broken

MUCH has been written and said in the past two years on the matter of our foreign trade and particularly with reference to our relations with Latin America. This is a subject of vital interest to our young engineers, for it is through this work of developing our trade that they are finding new fields of endeavor—particularly those who have a liking for pioneer work.

The engineers' relation to this work is a matter which should be of extreme interest to commercial men, for in the last analysis, the engineer is the scout for our army of commercial invasion, and as a "trade-getter" must be reckoned with.

The past two years have seen great improvements in our methods employed to capture this trade, and in our methods of handling it after it is ours. This has come through careful study of conditions and the resulting increased understanding of our neighbors, and their wants and needs.

However, our handicap does not consist solely of this lack of knowledge and experience—our heaviest handicap lies in characteristics which are peculiarly Anglo-Saxon.

In the American this is expressed by a marked contempt for, and a suspicion of, anything not American. This, in the writer's opinion, is one of the greatest obstacles we have to overcome in our effort to take our rightful place in Latin American relations.

The Latins are as distrustful of us as we are of them—a situation brought about through lack of understanding—or perhaps through lack of effort to understand. The fault lies with ourselves, for we seem to forget that we are foreigners and that the obligation lies with us. There are Americans in South America who seem to hold to the belief that English should be spoken everywhere for our convenience.

German success in the foreign field is largely due to the attitude of the German toward the land of his adoption, for unlike the American, he becomes truly a part of the country in which he is earning his livelihood. He soon speaks Spanish fluently, so eventually, he usually marries a South American, and as nearly as possible adopts the customs of the country. It is seldom that a German returns to his native land.

On the other hand the American is inclined to look upon foreign service as a transient condition. He is usually a poor linguist—largely because of a lack of interest in his new surroundings. To develop to the fullest extent his potentialities to benefit his country, the engineer in foreign service should aim to school his mind so as to become as much as possible a part of the country.

South America offers a life of keen interest to the engineer. There, as in no other part of the world, can he satisfy his craving to create. Most of his work is connected with large enterprises. Probably nowhere else is such great potential wealth coupled with such lack of development as is evidenced in the Andes. It is said that the Andes contain every known mineral—and the statement is probably true. There are many other resources—notably agricultural, which will lead eventually to great developments in irrigation and drainage.

The Andes are also rich in water power—a fact very soon impressed upon the traveller. Splendid power sites are available at altitudes as high as 14,000 feet. Streams at this elevation combine precipitous descent with steadiness of flow which is most unusual. This is due to the fact that the water is stored in glaciers, to be drawn upon during the dry season. Small reservoir sites abound, and these can be cheaply developed and used as regulators for this glacial supply. At present, of course, these sites are valueless except as they may be utilized in connection with mining.

Repairing a Penstock Break in the High Andes

One of the greatest needs is a comprehensive system of railroads. Railway construction is extremely difficult and expensive and taxes the ingenuity of the engineer to the utmost. Little can be expected along this line, except in connection with mining, for this is the only traffic able to bear the burden of the heavy capitalization involved. Here is a large future field for hydroelectric activity. Fuel in the higher altitudes, notably in Bolivia, is very expensive, and electrification of these railways would

prove an economy even with a comparatively low traffic density.

At present the crying need of all West Coast countries is capital. This, of course, for some time to come will only be attracted through the opportunities to be found in the mining field. So, in the last analysis, the development of all other resources will be dependent upon the mineral wealth of these mountains. The completion of many of the projected mining railroads will open vast areas of rich agricultural land on the Eastern slopes of the Andean ridge.

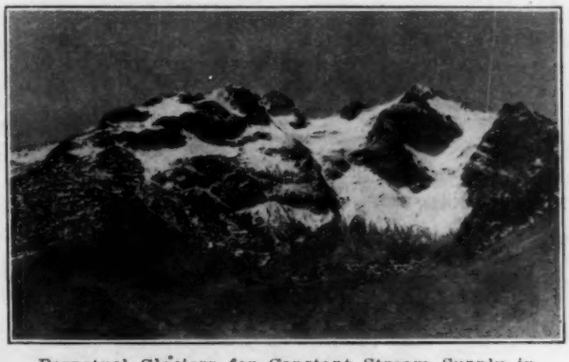
Capital, in the past, has been very timid about entering these lands of opportunity because of their political instability. This condition, happily, is rapidly becoming a matter of history. The day of the opera bouffe revolution is passed and the governments of these republics are coming more and more to realize their economic needs. With this realization is coming a more encouraging attitude toward foreign capital and at the present time, this means American capital.

This in turn means greater opportunities for American engineers. A word of warning here, will probably not be amiss, although it has been given by many writers before. This is in reference to the danger of going to South America on "spec." One should have a contract, or at least a promise of something definite before venturing into the foreign field. Unemployed foreigners are usually regarded with suspicion and the positions offered are not likely to prove very attractive.

Among the more promising fields may be mentioned sales engineering. The large trading companies such as W. R. Grace & Co., employ many engineers in this capacity.

The foregoing is not intended to give the impression that success is to be attained with less effort abroad than at home. Opportunity certainly is more generous with her gifts—but character still remains the deciding factor. A young man is likely to be given responsibilities beyond his years and often the test in resourcefulness is very severe. Tact is always required to fill executive positions and this is particularly true in handling peon labor.

It must be borne in mind that every man is not fitted for foreign service—tact, resourcefulness and integrity are essential—as are also, a genuine love for the life and an understanding and liking for the people. Temptations are often great and many a life has been broken through homesickness. This is probably the greatest trial of all. The writer is careful about recommending foreign service unless he is sure of his man.



Perpetual Glaciers for Constant Stream Supply in Hydroelectric Development—Elevation 20,000 ft. on Divide Between Amazon and Pacific Drainage in Peru

Llama, the Burden-Bearers of the Andes, in Front of an Ancient Piece of Inca Masonry

To some, the life is fascinating and full of interest. The South American will usually be found to be extremely hospitable and courteous, in both social and business relations. The life need never be dull; for though one may suffer greatly from nostalgia, it will be found that the foreign colony offers many diversions for the new comer.

CHINESE WOOD-OIL INDUSTRY

One of the most important of Chinese products—and one for which Hankow acts as the chief exporting center—is t'ung-yu or wood oil. This oil is obtained from two varieties of Aleurites, a small genus of the spurge family. Each variety has rather sharply defined boundaries, the mu-yu shu or wood-oil tree being found for the most part in the southern Provinces, while the t'ung-yu shu, literally tung-oil tree, is confined largely to central and western China. By chemical analysis the oils of these two trees are found to be practically the same, but the t'ung-yu shu is of far more importance because of its greater hardihood and wider distribution. Fully nine-tenths of the so-called wood oil exported from China is made from this variety.

T'ung-yu is used as an adulterant in the manufacture of lacquer varnish, as an illuminant, and as an ingredient in concrete, and when mixed with lime and bamboo shavings it is used by the natives in calking their boats.

USE OF BOILERS IN ARGENTINA

British-made boilers are so generally used throughout Argentina that they are regarded as the standard, and contractors, constructors, and engineers who are practically all either Argentinians or Europeans, are more accustomed to work with British boilers in their plans, construction work, and operations. The British boiler is somewhat of a different design and type to the American, the American boiler being lighter. The horsepower of the American boiler runs slightly over the rating as used in Argentina, based on the metric system of measuring heating surfaces. The metric system of measurement is legalized in Argentina and almost exclusively used.

SUGGESTIONS FOR CONTRACTOR AND DEALER

DEPARTMENT CONDUCTED BY GEORGE A. SCHNEIDER.

(Trade acceptances are entering more and more into the business activity of the contractor and dealer. Here is a timely discussion of the salient features of this form of credit so vital to future success in business enterprises home and abroad. Other subjects of current interest to the contractor and dealer are also discussed in this issue on dry cells, troubles with brushes and methods of connecting plug cut outs. The author is power apparatus specialist for a well known supply house in San Francisco.—The Editor.)

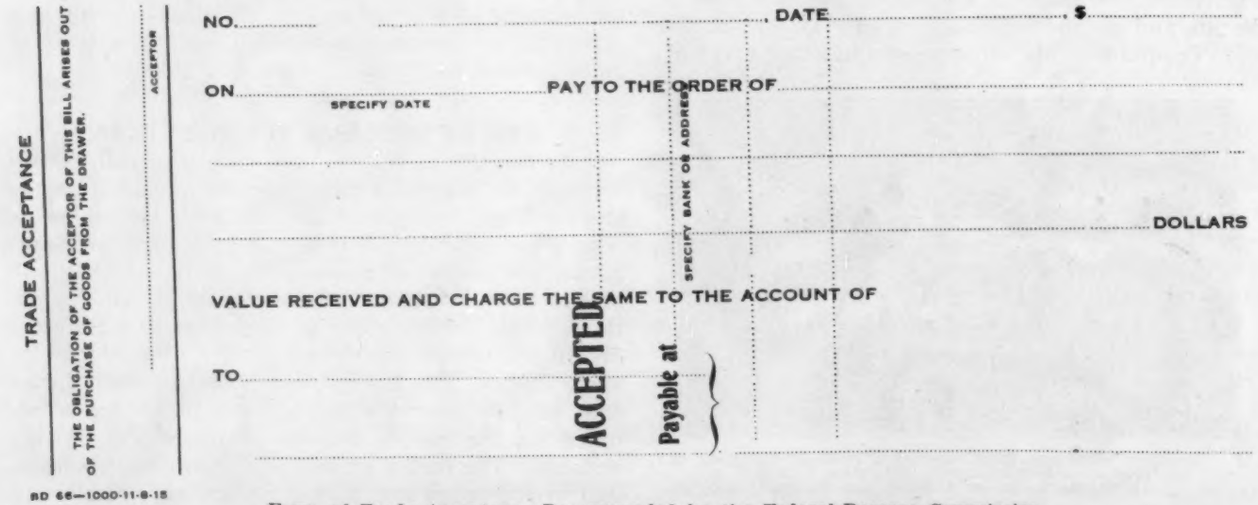
TRADE ACCEPTANCES

The subject of "Trade Acceptances" has been given and is continuing to receive considerable thought and study on the part of the electrical business man on the Pacific Coast. The plan appears to be in operation only in a limited way at the present time. It has been demonstrated in the brief experience that it cannot be used on any particular class of trade as a whole. It seemed to be the idea, up to a short time ago, to use it most entirely with the Contractor-Dealer customer. If that plan had been persisted in it would mean that a good part of the paper would have to be taken on liberal time allowances. There could be no serious objection to allowing some extra time by taking acceptances at longer than ninety days, provided interest at legal rates is paid, for it might be better for the supplier to have some few extended accounts in the shape of acceptances than to worry along with an open account. The customer who might be allowed such extra assistance would undoubtedly appreciate that his continued line of credit depended upon the faithful performance of meeting the acceptances without question at due dates.

The Contractor-Dealer is in about the same situation as the Supplier, in that he cannot hope to obtain acceptances from a majority of his customers. He will also be able to use the plan only in individual cases. Contracts almost invariably call for payments at stated periods in cash, or when certain work has been completed. It does not happen very frequently that the owner pleads for more time. If the owner needs more time he generally obtains it by putting in claims on the job. This is not in the main the reason for slowness in paying on the part of the Contractor-Dealer. The question of how soon the contractor can get his money in view of the stated time for payment in contracts depends in the long run on his ability as a collector. If he does not need to look out for his lien rights, acceptances should be secured when extra time is required, provided the customer is good for the amount, and there is a thorough understanding that no extension can be allowed.

The larger companies appear to be trying to work into the plan gradually with individuals, rather than groups of any particular classes of trade. It is quite generally understood that it will take time to secure the use of Trade Acceptances, universally, as in some of the European countries. The Book Account has been so long established that it will take some time to educate the public into making such a decided change in the manner of making settlements. The present plan is wrong, in that the merchant acts as banker for his customer when accounts are not paid on terms. Credit becomes Capital when bills are not paid at due dates. It appears to be possible to obtain relief from this burden in a limited way by the judicious use of the Trade Acceptance.

It will be necessary to make concessions in order to assist in getting the idea across, but the penalty should not be anything more than concessions of time. The banker must also assist by allowing a lower rate for discounting acceptances. In some cases a discount of 1 per cent is being allowed for thirty-day acceptances received on the 10th of the month covering the prior month's purchases. This works out to the extent that the customer obtains almost sixty days, for the account would average sixty days on the 15th of the month, five days after the due date of the accept-



Form of Trade Acceptance Recommended by the Federal Reserve Commission

ance, and obtains in addition 1 per cent cash discount. This is altogether too high a penalty, for when the supplier also pays his bank for discounting the paper, the net cost of the additional capital is so expensive that it would be impossible to make anything on it, even if the business were run on a very efficient basis.

In addition, the seller is carrying a contingent liability at the bank, for if the maker does not pay at due date the seller must. This works out to the end that the seller is "holding the sack" for both the bank and the buyer and paying for the privilege. This is not very satisfactory from the viewpoint of the seller. The buyer who does not cash discount, will take on the average sixty days and longer. He is the one from whom acceptances should be obtained. The seller would undoubtedly cancel his lien rights by taking an acceptance. This is only a minor angle, but it must be considered in individual cases.

This problem is one which the merchant must work out for himself to a large extent. A lot has been heard on the subject from bankers. Their views, while not entirely selfish, are based to some extent at least on benefits that will come to them in the shape of more desirable discount paper, also increasing the means for bank discounts, and in other ways acting to their advantage. One banker who has been very strong for the plan, has stated that it should not be used with the "slow pay," who generally does not know definitely when his accounts will be paid, owing to the nature of the business methods used, which give his customers little worry about settling up. He also remarked that a trade acceptance as against an open account in no way increases the ability of the customer to pay more promptly. He also considered it a blow to the plan to adopt it with any other class of trade than those who pay reasonably promptly.

The problem, as stated, must be worked out by the business man and not by the banker. If he takes acceptances from his good customers who pay promptly, he would be little better off than now, and would have the "slow pays" to still worry him. The acceptance is not going to benefit the seller on that class of customer. There are other things that must be worked out with the "slow pay" before the acceptance will enable him to pay more promptly. It may help some but not a great deal.

The plan, in general, must not be jeopardized by going at it in a hap-hazard way and without giving serious thought that there must not be any failure to pay at due date. Present business ethics require that bank checks be paid according to dates. A check returned from the bank marked "returned account insufficient funds" is enough to cancel the credit standing of the maker. The failure to pay a "Trade Acceptance" at due date should be made equally important as having funds in the bank to meet checks in payment of supplies. One or two houses who have used the plan report that 10 per cent of acceptances received have not been paid at maturity. This means that the plan has not been tried out on the right customer, but undoubtedly more care will be used as a result of experience obtained.

The "Trade Acceptance" plan can in time be worked to good advantage by the supplier and possibly the Contractor-Dealer to a lesser extent, but it must be applied only to that part of the trade which can be of help in putting it into successful operation. Any mis-steps made now will surely have bad effects in getting the plan in future time, into general operation.

INCREASING LIFE OF DRY CELLS

A well known manufacturer of battery cabinets especially designed for use with dry cells states that the average service life of a bank of such cells can be increased approximately fourfold by using double the number of cells ordinarily required in any particular installation. This statement is confirmed by actual life tests.

To obtain these results, the cells should be arranged in two banks connected in parallel thus reducing the drain on each bank to one-half of what it would be if used alone. The economic advantage of using two or more groups in parallel is especially noticeable when the cells are to be used for severe service as they would be for ignition purposes in connection with large gasoline engines or for similar service.

This scheme can also be used to very good advantage in small telephone exchanges where the ringing current is supplied by dry cells operating through an interrupter or pole-changer because during certain hours of the day the maximum current demand upon the battery will be considerable above the average and further may be required so frequently during the hours of rush business that the cells do not have time to recuperate.

For light service such as operating small annunciators, signal systems, individual telephones and the like, a single group of cells is usually more economical than two or more groups because any saving that might at first thought seem possible is offset by the deterioration caused by local action on standing.

TROUBLE DUE TO INCORRECT BRUSHES

Much of the trouble experienced with commutators can be traced to the careless substitution of carbon brushes. In connection with this statement it should always be remembered that the function of a brush is not only to collect current from the commutator but that it actually assists in commutating the current in the armature coils. Therefore when a brush differing in characteristics is substituted in place of that particular grade originally furnished with the machine or recommended by the manufacturer troubles may develop, some of which can ultimately prove expensive. These remarks apply also in a measure to brushes for collector rings.

PROPER METHOD OF CONNECTING PLUG CUT-OUTS

Some wiremen do not seem to know that there is a right and a wrong way of connecting the common main line plug cut-out into the circuit. The correct way is to place the cut-out so the inner contacts will be connected to the line or live side of the system, thus leaving the outer shells dead when the fuse plugs are not in place. When connected in this manner there is less likelihood of shock or accidental shirt-circuits.

ELECTRIC POWER FOR IRRIGATION PUMPING

DEPARTMENT CONDUCTED BY S. T. HARDING

(Chemi-hydrometry is daily solving more and more the problems of scientific and engineering measurement. In the issue of Feb. 15, 1917, results were set forth by operating engineers of the Pacific Gas & Electric Company wherein the electrical conductivity of boiler water and condensate was made use of due to its varying salinity, to ascertain the purity of water. Here is an excellent article wherein this author checks the accuracy and develops the theory for a method of flow measurement of water by injecting a salt solution of known weight. The author is professor of engineering mechanics at the University of California and a well-known authority on hydraulic research.—The Editor.)

A SMALL SCALE TEST OF FLOW BY CHEMI-HYDROMETRY

BY JOSEPH N. LE CONTE

A great many measurements of flow have lately been made using the method of chemi-hydrometry, or saline method. Many of these have been made on a very large scale, and with a great amount of care and refinement. Very few, however, have been checked against other methods of equal or superior refinement, because when carried on upon a large scale this becomes extremely difficult. The purpose of the following paper is to show that fair results may be obtained with ease on a small scale, even though great refinement is not attempted.

The measurement was made through a small centrifugal pump, for the reason that it furnished a convenient and easily regulated flow, and also because the mixing of the salt solution is so perfectly accomplished by the rotating impeller. The dosing solution was introduced into the suction elbow of the pump through a quarter-inch connection. The supply was drawn from a small tank mounted upon a platform scale whose beam was graduated to tenths of a pound. The connection between the tank and suction elbow was through a flexible rubber tube, and quick opening cock, whose handle operated between fixed steps. When this handle was so turned as to open the cock wide, the flow into the suction would be at a constant rate, provided the level of salt water in the tank was maintained at constant level. This condition was obtained by mounting a second similar tank and scale above the first, and keeping the level in the latter at a definite mark by hand regulation of the second. The total weight of dosing solution injected in a given time will then be the sum of the weights of the two tanks at the beginning, minus the sum of their weights at the end of the operation. One observer operates the quick opening cock, takes the time with a stop watch, and regulates the level of the salt water in the dosing tank. A second observer must take samples in clean bottles, of the dosing solution; of the original water, i.e., in the sump; and of the pump discharge while the dosing is going on.

The following is the theory in its simplest form. Let a saturated solution of salt of known concentration be injected into the suction at a known rate of **q** cubic feet per second. Let **b** be the weight of salt per cubic foot in **q**. Similarly let **Q** be the inflow through the main suction in cubic feet per second, and **B** be the weight of salt per cubic foot in **Q**. Finally, the outflow of the pump will be at the rate of $Q + q$ cubic feet per second, and the weight of salt per cubic foot in it can be represented by **A**.

Then,

$$qb + QB = (Q + q)A$$

$$\therefore Q = q\frac{b - A}{A - B} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

and

$$Q + q = q\frac{b - B}{A - B} \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Let **x** be the volume of an analysis sample of **q**, **X** be the corresponding volume of a sample of **Q**, and **Y** of $(Q + q)$.

The quantities **b**, **B**, and **A** are determined from the samples best by the titration method, that is, by measuring the amount of silver nitrate necessary to precipitate the silver chloride in the solutions using bichromate of potash as an indicator. The amount of silver chloride necessary will vary directly with the weight of salt in the sample, that is to say, directly as the weight of salt per unit volume, and as the volume of the analysis sample. Hence if **r** represents the cubic centimeters of silver nitrate solution necessary to precipitate **x**, **R** that necessary to precipitate **X**, and **S** that for **Y**, then

$$r = Kxb; \qquad R = KXB, \text{ and } S = KYA, \text{ and}$$

$$Q = q\frac{\frac{r}{Kx} - \frac{S}{KY}}{\frac{S}{KY} - \frac{R}{KX}} = q\frac{r - S\frac{X}{Y}}{S\frac{x}{Y} - R\frac{x}{X}} \quad \ldots\ldots\ldots\ldots (3)$$

$$Q + q = q\frac{r - R\frac{x}{X}}{S\frac{x}{Y} - R\frac{x}{X}} \quad \ldots\ldots\ldots\ldots (4)$$

This latter is generally the amount required.

Take the case of the small centrifugal pump already mentioned, where the salt solution was weighed out, and the true discharge $(Q + q)$ measured volumetrically in a large calibrated tank in order to check the accuracy of the method.

Gross weight of two tanks.....	57.10 lbs.
Tare	26.30 "
Pounds of salt solution used..	30.80 lbs.

Time, 4 minutes = 240 seconds.

Pounds of salt solution per second = 0.1283.

To convert this into cubic feet per second, we need the specific gravity of the dosing solution. This may

be obtained by an accurate hydrometer, or by chemical analysis using saline tables as follows:

Amount of sample used = **x** = 2 c.c.
Atomic weight of **Cl** = 35.45
" " **Na** = 23.00
" " **NaCl** = 58.45

Standard solution of nitrate of silver used contained 0.09951 grams per liter, and the amount of this necessary to precipitate the salt in the sample was 86.6 c.c.

$$\text{Weight of salt in 2 c.c.} = 86.6 \times 58.45 \times \frac{.09951}{1000}$$

$$= .5036 \text{ gram.}$$

Weight of salt in 1 c.c. = 0.2518 gr. (at 55° F.)
Hence from tables; Specific gravity is 1.163[1], and

$$\mathbf{q} = \text{vol. per sec.} = \frac{0.1283}{62.4 \times 1.163} = 0.001767$$

cubic feet per second continuous flow of dosing solution into the suction.
Now in the analysis:

x = 2 c.c. **X** = 200 c.c. **Y** = 200 c.c.
r = 86.6 c.c **R** = 1.67 c.c. **S** = 15.27 c.c.

$$\mathbf{Q} + \mathbf{q} = 0.001767 \frac{(86.6 - 1.67)\ 1/100}{(15.27 - 1.67)\ 1/100} = 1.125 \text{ sec. ft.}$$

This same quantity was measured by volumetric displacement in a concrete tank, which had previously been calibrated by actual weight This measurement was made while the dosing was going on.

Hook gauge at start..... 4.25
" " " finish..... 122.35
Rise in surface..... 118.10
Tank constant =1.523.

Total cubic feet of flow into tank = 118.10 × 1.523 or 180.0 cubic feet.

Time 2 minutes, 41 sec., or 261 sec. The actual rate of flow therefore was 1.118 sec. feet.

[1] Chemi-Hydrometry—Benj. F. Groat. Proc. A. S. C. E. Vol. XLI. No. 9 p 2111. Also Kent's Engineers' Handbook.

THE ECONOMICS OF PUMP IRRIGATION

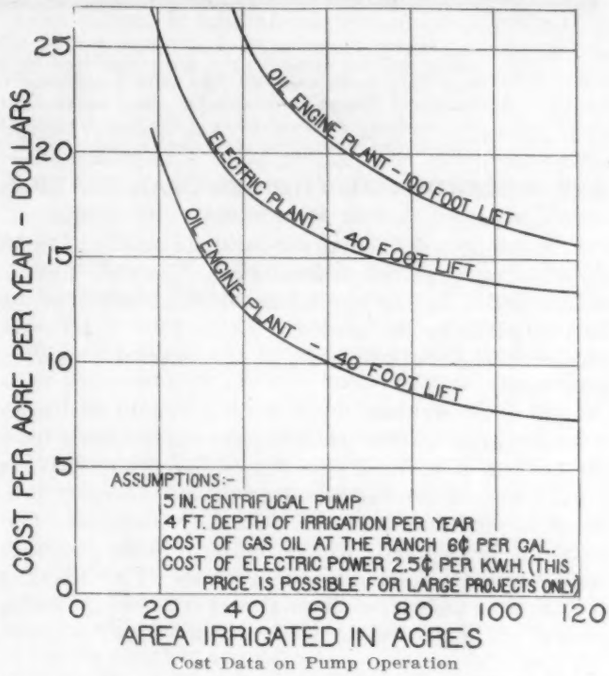
A study of the economics of pump irrigation has been made by the agricultural experiment station at Tucson, Arizona. The influence of acreage upon the cost of pumping is forcefully shown in the diagram given herewith which is taken from the twenty-sixth annual report of the station and which has just made its appearance. From this chart it is seen that pumping plants should be used continuously through the irrigating season and that a five inch centrifugal pump should supply water for at least 80 acres.

An Irrigation Laboratory Well

The University of Arizona has dug a pit to water level and installed a 16-inch stave pipe casing 200 ft. deeper in order to get experimental data on electrical pumping for irrigation. Tests are to be made on vertical pumps and much important data is expected leading to further economic uses of the electric pump.

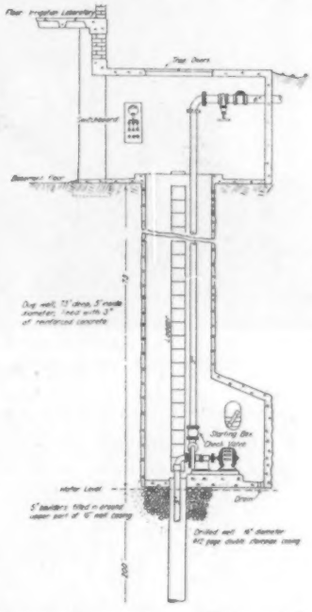
Pitless Pumps

Pitless vertical pumps with large bowls were first introduced in Arizona and California in 1909. They have come into use very rapidly and at the present



Cost Data on Pump Operation

time fully 50 per cent of the water pumped for irrigation in southern Arizona passes through pitless pumps. For several years the pumps of this type were brought into Arizona from Texas and in efficiency they did not measure up to that of the better class of pit pumps with which they came in compe-


An Experimental Pump at the University of Arizona

tition. Since 1912 the pitless pumps have been manufactured in California, and while the first ones showed no improvement, the California pumps made during the past year have been built on scientific designs, are of excellent efficiency, and comparatively free from mechanical troubles.

ELECTRIC COOKING AND HEATING

(Electric welding is of particular interest to the central station man. It offers an exceedingly valuable tool for quick repairs when employed by the company operators, and it also offers a profitable new load opportunity for the sales department thrroughout the industrial community served. Here are discussed "down-to-the-minute" ideas on this form of central station load. This paper was delivered before the recent convention of the New Mexico Electrical Association by the author, who is professor of electrical engineering at the state college, which is situated at Las Cruces, N. M.—The Editor.)

ARC WELDING FOR THE CENTRAL STATION

BY R. W. GODDARD

Welding is defined as the intimate and permanent union of two pieces of material. Usually this is accomplished by the application of heat and pressure to the parts to be welded. These two factors are produced in different ways in the several processes used today.

In forge welding, heat is produced in the work from a coal or oil fire while pressure is obtained from the blow of a hammer. In the oxy-acetylene process a gas flame of great concentration and intensity produces the required heat to actually melt the material to be worked, which naturally runs together and becomes a solid mass on cooling. The Thermit process also melts the material and is really a casting method. The process is purely chemical and is based upon the fact that metallic aluminum has a great affinity for oxygen and will under proper conditions reduce certain metal compounds, with the production of an intense heat. Finely powdered aluminum is mixed with iron oxide and placed in a crucible over the properly prepared work. This is ignited by a fuse which starts the action. The heat of combination melts the entire mass, the iron liberated from its oxygen sinks to the bottom, while the aluminum united with the oxygen rises to the top. At the right time, the tap in the bottom of the crucible is drawn, allowing the molten iron to flow into the work, firmly uniting it on cooling.

Repairing Steel Casting with the Lincoln Arc Welder.

In the electric resistance method of welding, use is made of the heat generated in a conductor of electricity. A contact between two conductors offers greater resistance than the conductors themselves and consequently becomes heated to a higher temperature. This heat is on the passage of a heavy current, great enough to fuse the ends of the conductors together with the help of a little outside pressure. This process uses alternating current and is utilized to a large and ever increasing extent in the industries. A later, process, known as the electric percussion method works upon the same principles but here the process is instantaneous in action and results from the sudden blow of one part upon the other. The pressure is from the blow, while the heat is produced by the sudden discharge of a condenser through the joint to be welded at the instant of impact. Because of the speed of the operation the heat is localized in the joint and does not extend back into either part. This feature is valuable in certain classes of work as well as very economical of the power utilized in the poduction of the wold.

The art of Electric Arc Welding is divided into two general classes, namely: the carbon electrode method, and the metal electrode method, each having slightly different procedures. In either case fusion is the result the intense heat produced by a direct current arc. The arc may be between two electrodes held over the work and be deflected down upon it by magnetic or an air blast as in the Zerener and Werdner processes, (1) or between a single electrode and the work itself as is done exclusively in this country. In the carbon electrode process this single electrode is a carbon rod supported in a suitable holder, while in the metal electrode method it is a metal rod clamped in a feeding tool.

The process of electric arc welding is of particular interest to the central station man as it offers an exceedingly valuable tool for quick repairs with a negligible expense. Its value is chiefly in case of emergency to prevent or shorten the length of an enforced shutdown due to breakage of parts of the equipment or other accidents. Its use is not limited to what has been defined as welding. It will remove superfluous material, and cut sheet metal. It can be used to build up worn bearing surfaces or replace metal worn away in any manner. The innumerable uses to which the process can be successfully applied will suggest themselves to the central station man as they appear. I will, to illustrate the wide field covered, give a few applications which have been brought to my attention.

As examples of the straight weld may be mentioned broken cast iron or steel flanges and lugs, lever and crank arms, and innumerable small but important parts of machinery. More complicated jobs like welding new flues or stay bolts to tube sheets, piecing

old tubes with short lengths of new after they have been removed for leaky joints, repairing cracked mud drums and pipe fittings are successfully accomplished by this process. As these latter jobs require some degree of skill, the novice is warned not to attempt them until he has acquired by practice the necessary skill.

The cutting of sheet metal is one of the most useful applications of this process. Two notable examples of this might well be cited. At the New Mexico College of Agriculture and Mechanics Arts, we had an old rectangular tank built of very heavy sheet iron on an angle frame. This tank was just what was desired for a seasoning tank in the Material Testing Laboratory for concrete test beams, except that it was too deep. The problem was to cut away the top. Because of the springiness of the construction it was practically impossible to cut the sheet with a cold chisel and shearing was out of the question. A hack saw was tried with poor results, a wavy edge and many broken blades. The arc came to the rescue and in a very short time a clean straight line had been burned all the way around the tank, through the angle braces and all.

On Christmas day we had a very heavy wind storm in the southern part of the state. Many roofs and chimneys were blown away and among the latter were two of the three steel stacks of the Las Cruces Electric Light Company. These stacks both buckled about thirty-five feet from the top at the upper guy rings. The buckle extended completely across the stacks effectually cutting off the draught like a damper. The following evening I found Mr. Morgan, the manager, and his crew still trying to clear away the debris and open the standing part of the stacks with a cold chisel. He experienced the same trouble we at the college had with our tank. The cold chisel would bound off at every blow and made no progress. An offer of assistance was made and promptly accepted. I went out to the college, got my carbon welding electrode, lamp bank resistances, and hood and back to Las Cruces. The generator there is a 150 kw. General Electric machine with built in exciter. We removed the alternator field brushes and hooked on to the exciter brush holders, going through the lamp banks to a ground at a water pipe on one side, and on the other led a wire out to the boiler room roof and up the stack. The Corliss engine received sufficient steam to run the exciter from a small auxiliary boiler connected to the third and whole stack. In about four hours time the larger stack was wide open and ready for business. This time would of course been much less had we been able to get more current at the electrode. The fact that the work was some fifty feet in the air and the operator a very green steeple jack on an exceedingly insecure and wabbly ladder also delayed progress. With the large stack open, the plant was started up and with a small motor-generator set brought up from the college the next day, Mr. Morgan burned off the other stack.

These are but two of many possible applications for arc cutting. The removal of rusted bolts and rivets, the dismantling of old pipe lines, the cutting of openings in tanks and boilers for additional pipe connections and many others might be mentioned.

The building up of fresh material is also a notable advantage of this process. Probably the most common use of this feature is in the repair of grates. Holes burned in bars are easily and quickly filled up. It is not even necessary to remove them from the furnace. Worn key ways, cam surfaces, latch catches and tapets are all easily brought up to their original shape. Broken gear teeth may also be replaced. This is especially true of large cast iron gears where the tooth outline does not have to be extremely accurate. Samples of this class of work done at the New Mexico College of Agriculture and Mechanic Arts are broken S wrenches, and a brass gate valve, the whole side of which was broken out by freezing. This was replaced by removing the valve body, filling the shell with moist sand and melting copper into the brass and over the sand core. The S wrench would not seem a practical illustration as the added material has not the strength of the original, although experts claim to have produced welds stronger than the materials welded. At the college we have produced welds which have rebroken at points outside of the weld, but this is not in general true and cannot be depended upon.

Your natural question now is, "What do I need to produce these results?" The answer is simple: a source of direct potential, a current regulating resistance, a carbon or metal rod holder or both, and protective devices for the operator. In central stations the direct current is usually available from an exciter unit. The size of this is of small consequences, except that the larger the better and quicker are the results. At the college we have done successful welding with as small a machine as a three horsepower 110 volt, 24.5 ampere, direct current motor used as a generator and driven by a three horsepower, three-phase induction motor. In practice as large currents as 1500 amperes have been used. This is of course for very heavy work. The average currents used by plants in continual operation will run about 150 amperes for the metal electrode and 300 amperes for the carbon electrode. Regular welding generators are usually built to deliver from 300 to 600 amperes at approximately 60 volts. Any machine can be worked at a considerable overload in this service because of the fluctuating character of the load.

Since the electric arc in itself is unstable, there is necessary in its circuit some current regulating device. This is usually in the form of a low resistance connected in series with the arc. For the central station a suitable resistance is easily and quickly constructed of telephone wire run over porcelain knobs. The size and length of wire used will of course depend on the current desired and the voltage characistics of the generator. Usually an exciter may be connected directly to the arc without any series resistance in the circuit provided it is a compound wound machine and the series field is cut out. In this case the field is working at low flux densities and the armature reaction acts to produce the desired current regulation. This is also true of many shunt generators when working at 50 to 60 volts, but designed to deliver their maximum load at 110 to 125 volts. The exact conditions for any particular machine are best obtained by experiment, but when ex-

perimenting be sure the armature is well protected by fuses or circuit breaker.

The tools required are simplicity in the extreme. The carbon electrode consists of a graphite rod, ½ in. to 1½ in. in diameter, held in a clamp attached to a handle. Connection is made to the clamp by the terminal lug of the negative lead. The metal electrode is much the same, with the exception that it is made to take rods of approximately 3/16 in. diameter. The light from the arc, especially the metal to metal arc, is very rich in ultra violet rays and these cause severe burns if not prevented from striking the operator. A shield or hood protects his face and eyes, while gloves protect the hands. The hood is usually a cylinder of metal or fiber open at the top and bottom for ventilation and fitting down over the shoulders. A window of colored glasses in the front allows the operator to see his work. The glasses should be of sufficient density to prevent glare and eye strain due to the intensity of the light. Experience shows that a combination of green and orange gives the greatest satisfaction, allowing the operator to see the work as well as cutting down the intensity of the light from the arc enough to prevent eye strain. Fiber is to be preferred to metal for hoods as it is an insulator and cooler to work in. A supply of iron rods about 3/16 in. in diameter are needed for filling material or metal electrodes.

The manipulation is as easy as the apparatus is simple. As before stated, the work is made the positive electrode, since from a study of the direct current arc it is found that about 85 per cent of the power used is consumed at this point, thus liberating there the greatest quantity of energy. The generator is adjusted to deliver a potential of 45 volts by the field rheostat. The arc is struck by touching the negative electrode to the work and drawing it away. The length of the arc varies from ⅛ to ¼ in. with the metal electrode and from ½ to 3 or 4 in. with the carbon electrode. The electrode is given a circular motion to prevent too local heating and consequent burning of the work. Filling material comes from the electrode in the metal electrode process, while it is melted in by holding a 3/16 in. rod in the arc of the carbon electrode process. Current is regulated by adjusting the series resistance or the voltage of the generator. In welding thick pieces, the work must be prepared by cutting a V groove along the junction to allow the electrode to work at the bottom, the groove is then filled as the weld is completed. Care should be taken to see that the work is free from dirt and rust. This cleaning can be done by the arc itself if the current is heavy by melting the material and cleaning off the slag which rises to the surface. On large pieces trouble is often experienced with heat expansion and contraction. It is in this case generally desirable to heat the work to a dull red heat before welding. The weld on completion and while still white hot should be hammered as this drives out the gases which form in the molten metal and would otherwise form holes. It also tends to give the weld a denser and finer grain which of course adds to its strength. If possible anneal work after welding as this removes all strains set up by uneven cooling. This is particularly necessary if the work is to be machined.

Work with the carbon electrode is easier for the armature than with the metal electrode because of the necessity of maintaining a very exact length of arc with the latter. If drawn out too far it extinguishes itself, while if the metal electrode is allowed to touch the work it freezes to it. The carbon electrode is particularly adapted for all large work and necessary for cutting. The metal electrode works best on all small work, for building up new material, and for overload work. I believe the metal electrode process is the only one in which overhead work can be successfully done.

The use of flux in this work seems to be a matter of opinion with the operator. Some use it while others do not and produce just as good results. Borax or a mixture of red oxide of iron, 20 per cent, to borax, 80 per cent, are used.

Theoretically all metals may be welded by the electric arc process, but practically this is not true. Difficulty is experienced in preventing oxidation at the welding temperatures with zinc and aluminum. I have heard of aluminum being welded by surrounding the work with an inert gas. This may be done by putting the work in an air tight enclosure open only at the top. This is then filled with some inert dense gas which is confined by its density to the chamber. This can also be successfully accomplished by building a mold about the work and puddling the aluminum in the mold. The oxide then rises to the surface. The filling materials and metal electrodes are usually of the same material as the parts to be welded. For cast iron, malleable iron, and steel, a soft iron or mild steel is used. Recently experimental work has been conducted with success using alloys of steel where great hardness is required as in switch frogs and crossings in street railway work.

The following tables show the cutting speed and current required for steel plates of various thickness, as well as the results of some tests of various welds in iron and steel.

Table 1

Thickness Plate.	Current Amps.	Speed Cutting.
¼ in.	400	180 ft. per. hr.
⅜ in.	400	120 " " "
½ in.	400	50 " " "
¾ in.	400	20 " " "
1 in.	400	10 " " "
¾ in.	600	25 " " "
1 in.	600	16 " " "

Table II.—Results of Tests on Fire Welded and Electric-Welded Specimens

Brand Iron & Steel. Size of Bars. Strength in Tons of 2240 Pounds. Brand.	Size.	Kind Weld.	Ultimate Tensile Strength. Tons/in.²	Contraction of Area at Fracture. Per Cent.	Extension in Ten Inches. Per Cent	Ratio of Weld to Solid. Per Cent.
Lowmoor	2 in. x	Fire	20.4	15.9	8.1	82.3
Iron	⅞ in.	Electric	21.0	15.4	7.3	86.4
Lowmoor	2 in. x	Fire	20.3	15.2	7.3	77.9
Iron	⅞ in.	Electric	21.1	17.3	7.3	81.1
Netherton	2 in. x	Fire	21.5	22.3	11.3	90.7
Best Iron	¼ in.	Electric	21.8	20.7	9.7	91.8
Parkgate	2 in. x	Fire	18.4	10.1	3.4	84.4
Steel	½ in.	Electric	20.1	10.8	4.5	92.0
Parkgate	2 in. x	Fire	20.9	9.3	1.9	69.1
Steel	½ in.	Electric	22.3	18.4	3.8	73.6

References:

(1) University Colorado, Journal of Engineering, October, 1916, page 23.

(2) Illumination, Arcs. R. W. Goddard, page 61.

(3) University Colorado, Journal of Engineering, October, 1916, page 32, 33.

Electric Journal. E. S. Zuck, Vol. XI, page 37, Jan., 1914.

Electric Journal. E. S. Zuck, Vol. XI, page 565, Oct., 1914.

WESTERN ELECTRICAL ASSOCIATION MEETINGS

(Activity in affairs of the National Electric Light Association is to be observed on all sides throughout the West. The coming conventions of the Pacific Coast Section in April at Riverside and the Northwest Electric Light & Power Association in September at Spokane are interesting men of the industry on all sides. The convention of the New Mexico Electrical Association during the past two weeks described herein is typical of the happenings that are taking place in all sections of the West.—The Editor.)

CONVENTION OF NEW MEXICO ELECTRICAL ASSOCIATION

The third annual convention of the New Mexico Electrical Association at Albuquerque, Feb. 12, 13, 14, was in every way a success, there being a representative attendance, good papers, fine discussions and a hearty spirit of co-operation. From the social standpoint, also, banquets, a Jovian rejuvenation, round table discussions and a dance, contributed to the enjoyment of the thirty-five men registered.

Delegates and Squaws at the Convention of the New Mexico Electrical Association.

Having rounded out two years, this live organization enters on the third under the capable direction of M. R. Buchanan of Silver City, who is the newly elected president, J. R. Smith of Raton, first vice-president; D. W. Morgan of Las Cruces, first vice-president, and Jas. A. Shepard of Deming, secretary-treasurer. The new executive committee consists of past presidents C. M. Einhart of Roswell and W. P. Southard of Albuquerque; W. F. Ritter of Lordsburg, and Kenneth Myers of Gallup. The papers and discussions will be printed in their entirety, some appearing elsewhere in this issue. A brief summary of the salient points of the meeting follows:

The convention was opened on Monday morning with an address of welcome from M. L. Fox, editor of the Albuquerque Journal, with appropriate response by E. F. Sells. In his presidential address, W. P. Southard told of the past year's accomplishments and suggested a campaign of publicity to acquaint the people with the power companies' side as an object for the year to come.

Monday afternoon J. R. Smith gave a practical talk on "Efficiency in the Operation of an Electric Light Station," laying stress on the necessity for watching and correcting the leaks which increase the fuel bill. S. J. Ballinger read an excellent paper on "What the Power Company Should Tell the Public," his conclusion being "everything that they want to know," with the idea of allaying their groundless suspicions and gaining their confidence. He suggested that the electric meter might well be replaced by a clock if lamps were installed with the understanding that their use cost just so much per hour, depending upon the rate and the size of lamp. Prof. Goddard of the State College read a paper on "Electric Arc Welding for the Central Station," with special reference to the cutting of metals.

On Tuesday morning, J. F. Greenawalt presented a human interest story regarding the history and development of the telephone. L. A. Barley read a paper on "Standard Conduit Installation," the discussion therein being largely concerned with the detection, prosecution and protection against current theft. A. T. Slack spoke on the "Jobbers' Place in the Elec-

trical Industry," clearly demonstrating the necessity of the jobbers.

In the afternoon K. E. Van Kuran told what the electrical manufacturers are doing to help the power companies. A. H. Halloran gave an address on the past work and future plans of the Society for Electrical Development, and at a later date responded to the toast of the National Electric Light Association and its Pacific Coast section and at the Jovian rejuvenation gave the official obligation to the initiates. B. C. Westlake discussed "Transformers and Protective Devices," and Jas. A. Shepard presented a number of interesting operating wrinkles.

On Wednesday morning Prof. J. L. Brenneman read a paper on "Control of Off-Peak Loads," by a variation of the generating frequency. The ensuing discussion brought out the fact that a superimposed current was more practical and greater off-peak power consumption more desirable to the power company. W. O. Vickery read an instructive paper on "Standardization."

In the afternoon E. B. Glazier read a paper on "Relation of the Jobber to the Central Station." The "Question Box" was then opened and various matters discussed at length. The association voted that the Journal of Electricity be recognized as its official organ, passed a resolution endorsing the work of the Society of Electrical Development and adopted resolutions of condolence over the death of W. N. Berry, who had been elected secretary-treasurer. F. P. Woods paper on "The Meter and the Public" was read by title. Officers and executive committee for the ensuing year were regularly elected and a vote of thanks extended the retiring officers. In the absence of President-elect Buchanan, Vice-President J. R. Smith took the chair and briefly outlined tentative plans for the new year. Upon special request A. H. Halloran told how the association might conduct a campaign for bettering public relations in accordance with methods approved by the Society for Electrical Development. Some such action will be taken by the association this year, all the larger companies now being members of the Society. There being no further business the convention adjourned.

Social Features

The annual banquet of the association was held on Monday night at the Alvarado, J. F. Greenawalt being toastmaster. Other responses were made by H. A. Hibbard, the man of the watches; J. J. Cooper, J. A. Shepard, W. P. Southard, J. R. Smith, E. F. Sells and D. K. Sellers The menu and toasts were announced on a unique "load curve" in blue print form.

On Tuesday night six candidates were initiated in the Jovian Order by the "substitute ritual." J. J. Cooper told of the history and ideals of the order. Particular credit is due to H. A. Hibbard and E. A. Thiele for their efforts in conjunction with the rejuvenation and the joviation which followed, at which W. P. Southard presided. The following candidates were rejuvenated: Wm. W. Reddie, Sidney J. Ballinger, W. O. Vickery, W. F. Ritter, E. J. Van Buskirk and Chas. E. Twogood.

An enjoyable dance at the Alvarado on Wednesday night brought the festivities and activities of the convention to a pleasant close.

Those registered were as follows:

Prof. Reo. Goddard, State College, Las Cruces, N. M.
F. Schram, Roswell G. E. Co., Roswell, N. M.
Chas. E. Twogood, Albuquerque G. E. Co., Albuquerque, N. M.
John G. Koogler, Las Vegas L. & P. Co., Las Vegas, N. M.
S. J. Ballinger, Trinidad G. E. R. & T. Co., Trinidad, Colo.
W. O. Vickery, T. G. E. R. & T. Co., Trinidad, Colo.
Wm. W. Reddie, Western M. E. Co., Pittsburg.
B. E. Rowley, Hot Point, Denver.
—. Wightman, Trinidad G. E. R. & T. Co., Trinidad.
Prof. J. L. Brenneman, University of New Mexico, Albuquerque.
H. H. Jones, Cleveland Akron Bay Co., Cleveland.
Geo. Roslington, City Electric Co., Albuquerque.
A. H. Halloran, Journal of Electricity, San Francisco.
D. W. Morgan, Las Cruces Elec. Lt. & Ice Co., Las Cruces N. M.
J. R. Smith, Raton El. Lt. & Power Co., Raton, N. M.
C. M. Einhart, Roswell Gas & Elec. Co., Roswell, N. M.
E. A. Thiele, Roswell Gas & Elec. Co., Roswell, N. M.
L. A. Barley, Rocky Mountain Fire Underwriters, Denver, Colo.
W. P. Southard, Albuquerque Gas & Elec. Co., Albuquerque, N. M.
M. Nash, Nash Electric Co., Albuquerque, N. M.
H. A. Hibbard, Century Bldg., Denver, Colo.
B. C. J. Wheatlake, General Electric Co., Denver, Colo.
E. C. Armstrong, Nunn Elec. Co., Amarillo, Tex.
E. F. Sells, Westinghouse E. & M. Co., El Paso, Tex.
W. F. Ritter, Lordsburg Power Co., Lordsburg, N. M.
Jas. A. Shepard, Deming Ice & Elec Co., Deming, N. M.
E. B. Glazier, Krakauer, Zork & Moye, El Paso, Tex.
John J. Cooper, Mountain Elec. Co., Denver, Colo.
Thos. Marron, The Southwestern Mill & Elec. Co., San Marcial, N. M.
W. Albertson, New England Elec. Co., Denver, Colo.
A. T. Slack, Western Elec. Co., Denver, Colo.
P. Cameron, Albuquerque Foundry & Mch. Works, Albuquerque.
J. L. Nunn Nunn Elec. Co. Amarillo. Tex.
F. W. Fisher, Fairbanks, Morse & Co., Albuquerque, N. M.
N. R. Stansel, Southwest General Elec. Co., El Paso, Tex
J. F. Greenawalt, Mountain States T. & T. Co., Denver, Colo.

CCNVENTION OF PACIFIC COAST SECTION OF N. E. L. A.

Preparations for the convention of the Pacific Coast Section N. E. L. A., which is to meet at Riverside April 19, 20, 21, as announced in the last issue of the Journal, are growing apace.

A. B. West of the Southern Sierras Power Company, who is chairman of the committee on arrangements, held a meeting of his committee in Los Angeles, announcements concerning which will be given at a later date. The convention committee is as follows:

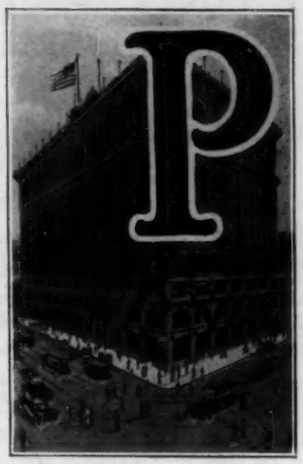
A. B. West, general chairman, and chairman entertainment committee, The Southern Sierras Power Co.
W. L. Frost, chairman attendance committee, Southern California Edison Co.
E. B. Strong, chairman transportation committee, Journal of Electricity.
W. W. Briggs, chairman reception committee, Great Western Power Co.
Henry Bostwick, chairman publicity committee, Pacific Gas & Electric Co.
D. M. Speed, chairman finance and auditing committee, San Joaquin Light & Power Corp.
G. B. McLean, Pacific Light & Power Corp., Los Angeles.
L. M. Klauber, San Diego Consolidated Gas & Electric Co.
E. R. Northmore, Los Angeles Gas & Electric Corporation

A committee of thirty, to be known as the membership committee of the Pacific Coast Section of the National Electric Light Association, is being appointed by President Ballad. Those members who have been appointed thus far are the following:

W. W. Briggs, chairman, Great Western Power Co., San Francisco, Cal.
C. A. Luckenbach, Los Angeles Gas & El. Co., Los Angeles, Cal.
Samuel Kahn, Western States Gas & Elec. Co., Stockton, Cal.
L. F. Galbraith, Pacific Gas & Elec. Co., San Francisco, Cal.
W. L. McKinley, Sierra & S. F. Power Co., San Francisco. Cal.
W. S. Coleman, Pacific Gas & Elec. Co., San Francisco, Cal.
S. J. Lisberger, Pacific Gas & Elec. Co. San Francisco, Cal.
W. F. Frost, Southern Cal. Edison Co., Los Angeles, Cal.
E. A. Quinn, San Joaquin Lt. & Pr. Co., Fresno, Cal.
Frank R. Russell, Tucson Gas, Elec. Lt. & Pr. Co., Tucson, Ariz.
J. B. Mechling, Nevada-California Pr. Co., Goldfield, Nevada.
Jas. A. Shepard, Deming Ice & Electric Co., Deming, N. M.
R. C. Lane, Upper Verde Public Utilities Co., Clarkdale, Ariz.
Ross B. Mateer, Southern Sierra Power Co., Riverside, Cal.
B. G. McBride, Elko-Lamoille Power Co., Elko Nevada.
R. S. Arthur, Douglas Traction & Light Co., Douglas. Ariz.
R. S. Masson, The Arizona Power Co., Los Angeles and Prescott.
R. E. Fisher, Pacific Gas & Electric Co., San Francisco, Cal.
Geo. B. Furness, Pacific Gas & Elec. Co., Oakland, Cal.

Great things are expected of this committee. Composed as it is of the ljvest and most enthusiastic group of Pacific Coast electrical men it is confidently expected by all that an unusual return will be made in new members by the time the convention opens in April.

SPOKANE CONVENTION OF N. E. L. AND P. ASSOCIATION



The Davenport Hotel at Spokane

PRESIDENT OSBORN of the Northwest Electric Light & Power Association has issued the call for the convention of the association which is to meet in Spokane during September of this year.

Spokane is beautiful at this period of the year and its location at the center of the great Inland Empire surrounded by agricultural and mining development, and nurtured by hydroelectric enterprises on all sides offers an unusual opportunity for a proper setting for the convention activities.

The text of President Osborn's call is as follows:

I have to announce appointments made at a meeting of the program committee in Portland, Oregon, on January 26, 1917, for the convention to be held in Spokane, Washington, on September 12, 13, 14 and 15, 1917, as follows:

Program Committee

M. C. Osborn (Chairman), The Washington Water Power Co., Spokane.
L. A. McArthur, Pacific Power & Light Co., Portland.
A. C. McMicken, Portland Railway, L. & P. Co., Portland.
M. T. Crawford, Puget Sound Traction, L. & P. Co., Seattle.
J. S. Thornton, Willapa Electric Co., Raymond.

Besides the above named, the following gentlemen were present at the meeting, and assisted in the arrangement of the program:

W. J. Grambs, Puget Sound Traction, L. & P. Co., Seattle.
P. A. Bertrand, Grays Harbor Railway & Light Co., Aberdeen.
C. R. Young, Pacific Power & Light Co., Portland.

The program as laid out by your committee, as far as can be determined at this date, will, of course, be subject to changes due to reasons that cannot be foreseen at this time.

In the preparation of the program, it was decided by the committee that all papers should be of a composite nature, with an editor-chairman for each and assistants selected from the best talent we can secure from the various member companies, on the subjects to be discussed.

To prevent duplication of ideas, the editor-chairman of each paper will present for the association's deliberations the ideas of the various members of his committee in one paper, the main idea being to eliminate all theories and confine ourselves to results obtained in practice.

The Program

The Washington association of electrical contractors and dealers, which anticipates an attendance of 100, will hold its annual convention at the same time and place, (The Davenport Hotel), that we hold ours and will have a joint meeting with our association at the opening session, Wednesday, September 12, at 10:00 a.m., at which time the usual address of welcome by our mayor, a response, an address by the president of the association and the reports of committees, will be presented, and a paper by J. C. Ralston, a member of the American Society of Civil Engineers, entitled "Aphorisms."

Wednesday, September 12, 2:00 p. m.

Paper, "Practical Central Station Salesmanship."
Lewis A. McArthur (Editor-Chairman), Pacific Power & Light Company, Portland.
George Bowen, Northwestern Electric Co., Portland.
S. A. Hoag, Puget Sound T., L. & P. Co., Seattle.
H. W. Lines, Portland Ry., L. & P. Co., Portland.
Lewis A. Lewis, Washington Water P. Co., Spokane.

Thursday, September 13, 10:00 a. m.

George E. Quinan (Editor-Chairman), Puget Sound T., L. & P. Co., Seattle.
E. H. Le Tourneau, Portland Ry., L. & P. Co., Portland.
A. S. Hall, Pacific Power & Light Co., Pasco.
D. F. Henderson, Washington Water Power Co., Spokane.
L. T. Merwin, Northwestern Electric Co., Portland.

Thursday, September 13, 2:00 p. m.

Paper, "How the Engineer Can Assist the Commercial Department."
Paper, "Co-operation in Modern Home and Apartment House Wiring Practice."
A. C. McMicken (Editor-Chairman), Portland Ry., L. & P.. Co., Portland.
H. H. Scofield, Pacific Power & Light Co., Portland.
J. R. King, Puget Sound T., L. & P. Co., Seattle.
F. O. Broili, Northwestern Electric Co., Portland.
Foster Russell, Washington Water Power Co., Spokane.

Friday, September 14—Both Sessions

Range Committee.—Both sessions of Friday will be devoted to the report of the range committee. I am pleased to announce the acceptance of the chairmanship of this committee by Mr. W. R. Putnam of the Utah Power & Light Company, Salt Lake City, Utah. Mr. S. M. Kennedy of the Southern California Edison Company, Los Angeles, and Mr. S. V. Walton of the Pacific Gas & Electric Company, San Francisco, Cal., will also act on this committee the exact personnel of which, however, will be announced later by its chairman, Mr. W. R. Putnam.

In connection with the range committee report, a paper will be read by Mr. H. B. Peirce of The Washington Water Power Company, Spokane, Washington, on "Bus-Bar Diversity of Ranges" compiled from data gathered from the study of residential feeders and other sources.

Also a paper by Mr. B. L. Steele, professor of physics at the Washington State College, Pullman, Washington, entitled "Comparative Tests of Coal, Kerosene and Electricity for Cooking."

(a) "Cost of Typical Meal for Five Persons by Coal and by Electricity";

(b) "Cost of Cooking for Five Persons One Week, by Coal With Water-Back Attachment and Without Water-Back Attachment, and With Electricity";

(c) "Efficiency Tests on Coal Ranges, Kerosene Burners and Various Electric Ranges."

The "Experience and Wrinkles" paper read at the convention two years ago in Spokane, was thought to be of a great deal of value to the association and will be revived this year, edited by Lewis A. Lewis of The Washington Water Power Company, Spokane. The value and usefulness of this paper depends upon the entire membership of the association.

Spokane Won't Look Like This at the September Convention

A "Wrinkle" is defined as being "any device, short cut, method or experience which has been worked out and used to advantage in carrying out your business."

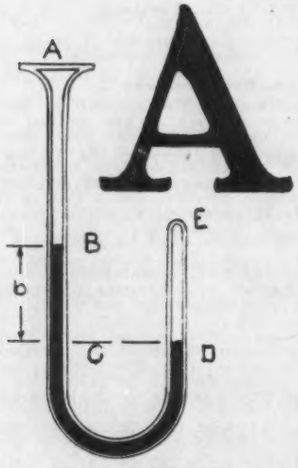
It is our intention to continue this broad definition and we are asking for contributions from as many departments and members as possible. There are many men connected with this association that have commendable ideas which cannot be elaborated into papers; these ideas properly come under the heading of "Wrinkles."

FUEL OIL AND STEAM ENGINEERING

(The laws of thermodynamics are so abstract, as a rule, that their meaning shoots clear over the head of the student in engineering application of these laws. In this article the author sets forth the elementary laws of thermodynamics used in fuel oil and steam engineering practice in such a way, it is believed, as to make them of ready application in all the simpler uses to which they may be put. With a clear conception of temperature and heat as herein set forth, one should be enabled to compute volumes and pressures of gases as occasion may arise.—The Editor.)

THE ELEMENTARY LAWS OF THERMODYNAMICS FOR FUEL OIL PRACTICE

BY ROBERT SIBLEY



The Establishment of Boyle's Law

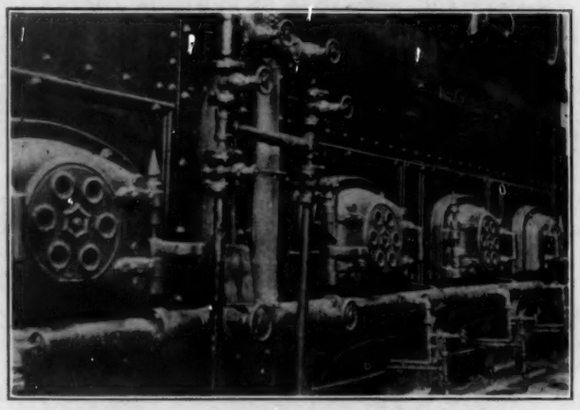
AS pointed out in the discussion on temperatures, scientists in former times conceived that the phenomena accompanying the addition or subtraction of heat could only be explained by the existence of a fluid which they called "caloric."

But these scientists or calorists, as they were called, had to give a hitherto unknown property to their substance and maintained that "caloric" was a weightless fluid. This substance also had the property of filling the interstices of bodies and of passing between bodies over any intervening space. To illustrate, they said, "caloric" would fill the interstices of a body as water enters a sponge. Now, when we squeeze a sponge some of the water oozes out and wets our hands. The calorists assumed that the friction or rubbing of a body with the hand for instance, made the hand warm because friction was supposed to decrease the capacity of a body for holding "caloric," and as in the squeezing of the sponge, water oozes out, so caloric oozed out and made the hand feel warm.

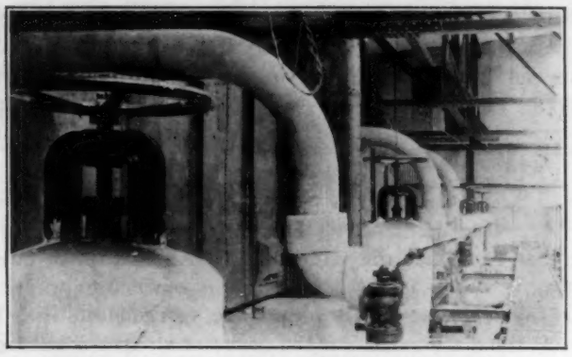
The Irrefutable Experiments of Davy.—Davy, however, exploded this theory in 1799, when by rubbing two pieces of ice together, he actually caused the ice to melt. This evidently would be impossible under the caloric theory above stated, according to which friction caused capacity for caloric to be decreased. Yet here was evidenced the adverse. From time immemorial, men have considered that the force of truth is almighty, and yet how slow the human race is to overthrow an imperfect but well-established theory. For instance, so powerful was Sir Isaac Newton's grip on the scientific world that because he announced that no successful correction could ever be made for the uneven refraction of light rays in lenses, the whole world for fifty years thoroughly abandoned the idea of ever being able to use refractive telescopes, and consequently, during that period we find telescopic reflective mirrors used entirely.

Joule's Complete Demonstration of the Mechanical Equivalent of Heat.—And so it was in the case of the theory of heat. Notwithstanding the all-powerful demonstration of Davy in 1799, it remained for Joule, nearly fifty years later to finally put forth the finishing data to forever overthrow the caloric theory and introduce the modern idea of heat. This eminent scientist constructed a machine in many respects similar to an ice-cream freezer, the essential difference being, however, that the machine was used to increase the heat in the liquid instead of cooling the same. Joule conceived the idea that heat was one form of energy. Should this be true, it should be mutually convertible. One of the easiest methods of measuring energy is the well known pile driver. Energy is definitely computed by weighing the hammer in pounds and multiplying this weight by the distance in feet through which the weight falls. The result is foot pounds energy. By a clever contrivance constructed somewhat on this principle, Joule measured the amount of energy absorbed in his machine and the consequent rise of temperature in the liquid. He soon established the fact that a definite number of foot-pounds of mechanical energy was equivalent to a definite number of heat units in the liquid. This experimental result is most important and is one of the basic principles of modern engineering. Careful scientific measurements have proved that one British thermal unit, or B.t.u. of heat energy is equivalent to 777.5 foot-pounds of mechanical energy.

The First Law of Thermodynamics.—From this discussion it follows that the first and greatest law of thermodynamics is the mathematical expression of the fact that heat energy and mechanical energy are mutually interchangeable. Thus if **W** represents energy in foot-pounds; **H**, energy in heat units; and **J**, this experimentally determined constant, we have the relationship



The Furnace Gases and Entering Air Obey Rigid but Simple Thermodynamic Laws. (Boiler Fronts at Long Beach Plant of the Southern California Edison Company.)



Superheated Steam Approximately Obeys Simple Thermodynamic Laws, (Superheated Steam Ducts of Station C of the Pacific Gas & Electric Company in Oakland.)

$$W = HJ \quad \ldots\ldots (1)$$

In steam engineering practice **H** is usually expressed in B.t.u. and the quantity **J** has a value of 777.5 as has been stated above. In other words, 1 B.t.u. of heat energy is equivalent to 777.5 ft. lb. of mechanical energy. In the chapter on units, we have defined the fundamental unit of energy, namely the foot-pound. This unit of heat energy now introduced, known as the British thermal unit is the 1/180th part of the heat necessary to raise one pound of water from 32° F. to 212° F. under standard atmospheric conditions of pressure. This is the unit which has been adopted by Marks and Davis, in their "Steam Tables and Diagrams" and although differing from other previously existing units is nevertheless practically universally adopted at this time.

Boyle's Law. Early in the last century, Boyle established the fact that a perfect gas, such as air, follows very closely the law known as Boyle's law, that the product of its pressure and volume is always constant provided the temperature is kept constant. Expressing this in mathematical symbols, if **p** is the absolute pressure in lb. per sq. ft.; **v**, the volume in cu. ft. cccupied by 1 lb., we have the relationship

$$p\,v = p_o\,v_o \quad \ldots\ldots (2)$$

Steam is not a perfect gas and hence does not obey this law with exactness, still the formula may be used with a fair degree of accuracy when considering superheated steam. Accurate formulas will be given later for steam variation. As an instance, however, of approximate computation, let us consider a boiler operating at 186.3 lb. gage or 201 lb. absolute pressure per sq. in., and producing superheated steam at 527° F. If we know the volume at one pressure we may ascertain approximately the volume at another pressure. In the steam tables the volume of steam at 201 lb. pressure per sq. in. is found to be 2.83 cu. ft. per lb. Hence at 250 lb. pressure the volume would become

$$v = \frac{200 \times 2.83}{250} = 2.26 \text{ cu. ft. per lb.}$$

The steam tables give this quantity by actual experiment as 2.31. Hence the formula is seen to work with superheated steam within 2 per cent of accuracy. For chimney flue gases and air, however, Boyle's law is very exact.

Charles' Law. In 1806 another law was found connecting the variables of a perfect gas. This great law, known as Charles' Law sets forth the fact that when the pressure is kept constant the volume of a gas increases proportionately to the increase in temperature. Thus if **t** is the temperature in degrees Fahrenheit this law states that

$$v = v_o\left(1 + \frac{t - 32}{491.6}\right) \quad \ldots\ldots (3)$$

As an illustration, if we wish to compute the volume that 1 lb. of air would occupy in a furnace at 2100° F., knowing that v_o has a value of 12.39 cu. ft. for air at 32° F. then $v = 12.39\left(1 + \frac{2100 - 32}{491.6}\right) = 69.8$ cu. ft.

The Absolute Scale. The establishment of this law indicates the fact that all temperatures should naturally be measured from a point other than that of the freezing temperature of water. Thus it is seen from the above that a point of 459.6° below the ordinary Fahrenheit scale would be known as an absolute zero. Throughout this work then **T** will represent the absolute scale and **t** the ordinary scale. Thus

$$T = t + 459.6 \quad \ldots\ldots (4)$$

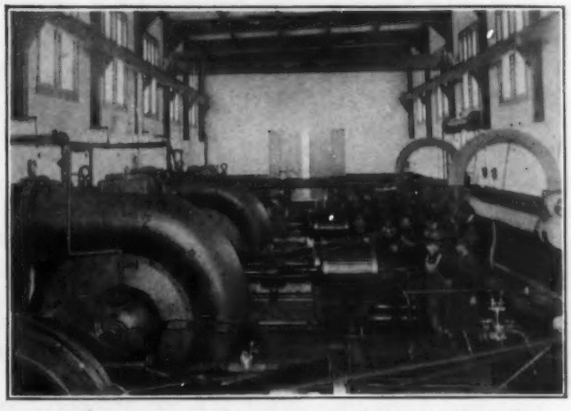
The Composite Law of Gases.—Since it is seen that the product of the pressure and volume is proportional to the change in absolute temperature we shall now write one of the most useful formulas in the computation of gas constants, namely that

$$pv = RT \quad \ldots\ldots (5)$$

in which **R** is a constant.

In the case of air, let us see if we can compute this constant. Experimentally it is found that the volume of air in a boiler room temperature of 84° F. is 13.71 cu. ft. per lb. when the atmospheric pressure is 14.7 lb. per sq. in. Substituting in the above formula we have $14.7 \times 144 \times 13.71 = R\,(459.6 + 84)$. Therefore $R = 53.3$.

A Formula for Gas Density.—If we let γ be the density of a gas, it is evident that it has a value equal to the reciprocal of **v** in the above equation In other words the density of a gas is the weight of 1 cu. ft under standard conditions of pressure and temperature. We may then write without further proof the formula,



Saturated Steam Obeys not at all the Simple Laws of Thermodynamics. (Circulating Water Pumps Operated by Saturated Steam at the Redondo Plant of the Pacific Light & Power Corporation.)

$$R\gamma = \frac{p}{T} \quad \ldots\ldots (6)$$

To Compute "R" for Any Gas.—In the measurement of gases there is a standard pressure and temperature to which all gas volumes and densities are reduced in order to have some basis of comparison. These standard conditions are the temperature of freezing water and the pressure of the atmosphere at sea-level.

From the equation last written above, it is now evident that since **p** and **T** are constant for all gases under this standardized method of comparison, then the product of **R** and γ must also be constant. This gives us a method or rather formula by which we may obtain the value of **R** for any gas if we know its molecular weight. The molecular weights of all gases may be obtained by reference to any standard book on elementary chemistry.

Let us multiply both sides of the above equation by the molecular weight **m** and by rearranging the terms, we have

$$Rm = \frac{pm}{\gamma T}$$

For oxygen $\gamma = 0.089222$ lb. per cu. ft. at atmospheric pressure and 32° F. and $m = 32$.

$$\therefore Rm = \frac{14.7 \times 144 \times 32}{0.089222 \times 491.6} = 1544.$$

Since this product **Rm** is always a constant, we have for any perfect gas that

$$R = \frac{1544}{m} \quad \ldots\ldots (7)$$

This formula together with the preceding general formulas for pressures and volumes now enables us to ascertain practically all the constants for perfect gases.

As an example let us assume that the temperature of an escaping chimney gas is 400° F. What would be the density of the nitrogen content of the escaping flue gases? First find the value for **R** for nitrogen for which $m = 28$.

$$\therefore R = \frac{1544}{28} = 54.98$$

Hence since

$$R\gamma = \frac{p}{T}$$

$$\text{We have } 54.98\gamma = \frac{14.7 \times 144}{459.6 + 400}$$

$$\therefore \gamma = .04475$$

It is always convenient to express volumes as the number of cu. ft. per lb. Hence when the symbol **V** is used it will mean the total volume content of the gas under consideration. If **M** represents the weight of this volume **V** we have the relationship

$$Mv = V \quad \ldots\ldots (8)$$

or since $pv = R \times T$, therefore

$$pV = M \times RT \quad \ldots\ldots (9)$$

Thus if we have given 18.805 lb. of dry flue gas we can easily compute the volume it would occupy when leaving the chimney at 400° F., if it is known that the value of **R** for the chimney gas is 51.4. Thus

$$14.7 \times 144\,V = 18.805 \times 51.4 \times (400 + 459.6)$$

$$\therefore V = 393.5 \text{ cu. ft.}$$

Further Illustrative Examples.—In order to still further illustrate the wide uses to which the formulas above given may be applied in engineering practice, the following seven problems are worked out in full:

1. Find the volume of one pound of air in a compressor at a pressure of 100 lbs. square inch, the temperature being 32° F.

From Boyle's Law:

$$p\,v = p_o\,v_o$$

at 32° F., v_o for 1 lb. of air is 12.39 cu, ft. and $p_o = 14.7 \times 144$

$$\therefore v = \frac{14.7 \times 144 \times 12.39}{100 \times 144} = 1.82 \text{ cu. ft.—Ans.}$$

2. From Charles' Law find the volume of one lb of air at atmospheric pressure and 72° F.

$$v = v_o\left(1 + \frac{t - 32}{491.6}\right) = 12.39\left(1 + \frac{72 - 32}{491.6}\right) = 13.4 \text{ cu. ft.—Ans.}$$

3. Find the temperature of two ounces of hydrogen contained in one gallon flask and exerting a pressure of 10,000 lbs. per sq. in.

2 oz. = 1 gal.

16 oz. = 1 lb. or 8 gals = 1.068 cu. ft.

$$\text{Then } T = \frac{pv}{R} = \frac{10{,}000 \times 144 \times 1.068}{765.86}$$

$$\therefore T = 2050° \text{ F. (abs.)—Ans.}$$

$$\text{or } t = 2050 - 459.6 = 1590.4° \text{ F.—Ans.}$$

4. How large a flask will contain 1 lb. of Nitrogen at 3200 lbs. per sq. in. pressure and 70° F.?

$p = 3200 \times 144$, $T = 459.6 + 70 = 529.6$, $R = 54.98$

$$pv = RT \qquad v = \frac{RT}{p}$$

$$\therefore v = \frac{54.98 \times 529.6}{3200 \times 144} = .0631 \text{ cu. ft.—Ans.}$$

5. Ten lbs. of air at 200° F. occupy 120 cu. ft. What must be the pressure?

$V = 120$
$M = 10$
$R = 53.33$
$T = 659.6$

$$\therefore p = \frac{MRT}{V} = \frac{10 \times 53.3 \times 659.6}{120} = 2950 \text{ lb. per sq. ft. —Ans.}$$

6. How many lbs. of air does it take to fill 5600 cu. ft. at 15 lbs. per sq. in. pressure and 60° F.?

$pV = MRT$

$V = 5600$ $p = 15 \times 144$ $R = 53.3$ $T = 459.6 + 60 = 519.6$

$$\therefore M = \frac{15 \times 144 \times 5600}{53.3 \times 519.6} = 437 \text{ lbs.—Ans.}$$

7. At what temperature will ten lbs. of CO_2 at 15 lb. per sq. in pressure fill 60 cu. ft.?

$$pV = MRT \qquad R = \frac{1544}{m} = \frac{1544}{44}$$

$p = 15 \times 144$, $V = 60$, $M = 10$. $\therefore R = 35.09$

$$\therefore T = \frac{pV}{MR} = \frac{15 \times 144 \times 60}{10 \times 35.09} = 369.2° \text{ F. (abs.)—Ans.}$$

$$\therefore t = T - 459.6 = 369.2 - 459.6 = 90.4° \text{ F.—Ans.}$$

SPARKS—Current Facts, Figures and Fancy

(A little here and a little there, gradually absorbed, is the way most of us build up our store of knowledge and acquire ideas for new enterprises in our respective lines. From this page may be gleaned perchance, something that may serve you in inspiration and creative imagination for the tasks ahead of you.—The Editor.)

Says the Bureau of Safety at Chicago: "You bet your life when you are thoughtless and careless about your work."

* * *

Why not think more earnestly of the wise saying of Jim Hill the Empire Builder: "Men who succeed are not magicians, but they have a capacity for hard work. If causes are created, effects must come."

* * *

The great German poet, Goethe, sent forth a truism that may well be called to mind in every effort electrical as well as in the other affairs of men: "The great part is not to pull down but to build up, and in this humanity finds pure joy."

* * *

Next to electric current, the most serious accidents are caused by falls and also the greatest number of days' lost time may be charged to this cause. This enters into every branch of the work, construction, operation, distribution and even the office.

* * *

First has come the use of radium salts to illuminate the hands of a watch so that time is easily told in the darkest surroundings. Now comes the same application for all kinds of push button apparatus, making it possible for a person to easily locate push buttons and other objects in an unlighted room.

* * *

By midsummer two mills having a total daily capacity of handling four hundred tons of tungsten ore deposits in Inyo County of California will have been completed and put in active operation. It may be that electric lamp companies will some day get all their supply for Western markets from Western sources. Who knows?

* * *

The latest in mammoth industrial centralization activity has recently been proposed by the Southern Pacific Company. This company offers to trade the city of San Francisco certain valuable lots on Van Ness avenue for the city's holdings on Channel street where the company would invest ten million dollars for creating manufacturing, wharfage and depot facilities on a scale hitherto unattempted in the West.

* * *

Lithographic stone, due to the high cost of quarrying and preparing for competition with the well-known Bavarian stones has been produced but little in the United States in the past. Kentucky stone is now profitably entering the market at five to six cents per pound for ten by twelve inch slabs and poorer grades, at one and one-half cents a pound for slabs of the same size. Why should not the West with its exceptional power rates and undeveloped quarries now enter this market?

* * *

The International Institute of Agriculture, since making an extended investigation as to whether the world has enough to live on during the coming year after taking into account the coming harvests in the southern hemisphere, reports that the whole world's surplus for the five great cereals will be about two-thirds of a billion bushels and the total surplus at the disposal of international trade as over fifty million bushels. Consequently it looks as if we might all pull through another year.

* * *

Electrical operation of trains entering long tunnels may find another application soon. General Chittenden, a retired member of the U. S. Engineer Corps, now chairman of the Port Commission of Seattle, Wash., has projected a plan to drive a thirty-mile tunnel under the Cascade Mountains to improve traffic facilities between ports on Puget Sound and the interior of the state. Such a project might cost fifty million dollars, but it would save fifty-eight miles of haul, reduce the summit elevation by over two thousand feet and the maximum grade from two and two-tenths to but six-tenths of a per cent.

* * *

Roy Thompson, a youth of Sacramento, California, is said to have invented an electrical device, which by means of two masts, seventy-five and one hundred fifty feet high, and eighteen hundred feet of barbed wire in the aerial, can operate a specially wound motor so that his home may be illuminated. That wireless transmission of power is possible has been known for some time and it is believed inventors will some day bring out a useful and efficient method of application. We must remember, however, that this energy can not be pulled out of the air without having some reservoir of supply whence it comes.

* * *

Due to the frequent indifference for small crops and diversified production found among Argentine farmers that country, in spite of being a primarily agricultural country, is dependent to a large extent on imports for its supply of beans, peas, and chick-peas. How our South American neighbors would hasten to install electrical pumps for irrigation if they heard of the high cost of beans said to prevail in Sacramento, California, recently, where a bartender is said to have taken up the three beans thrown on the counter by his customer, rung-up fifteen cents on the cash register for the drink furnished and returned eighty-five cents in change!

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IF IT'S WAR, HOW ABOUT YOU?

Engineers of the West see in the ultimate fruition of their present peaceful pursuits a creation that will raise the standard of human happiness and ease the burdens that attempt to crush the human race. If, however, for a season we must seemingly put aside our labors of peace to assume the sombre sober role of national defense let us do it bereft of hatred, with charity toward all and apply to the reharmonizing of world forces that same hearty, joyous, life-giving effulgence so characteristic of the freedom we breathe on every side in our Western Empire. Let us remember that in the last analysis mankind can only reach the harmony of being when freed from dominating influence both at home and abroad.

Bank Acceptances in the Electrical Industries

Much discussion has recently taken place in the columns of this journal relative to the use of bank acceptances in the electrical industry. On another page of this issue will be found a form advised by the Federal Reserve Commission.

In the local uses among contractors and dealers the acceptance is each day proving its usefulness in broadening the working capital and speeding the number of times of "turn over" of this capital during the year.

In the foreign field the American bank acceptance is a novelty in the commercial life of the country. According to a prominent banker of New York City, the commercial community of the United States has for years been deprived of the use of this most essential instrument of commerce due to the peculiar laws that have been in existence for years past. This same authority goes on to state that the potentiality of this new instrument is incalculable, and as time goes on its benefits will be appreciated far and wide.

A list of over one hundred and fifty articles of merchandise has been brought into this country last year by means of commercial letters of credit representing a total valuation of over thirty-five million dollars.

The value to the West of the future development of the letter of credit business is of vital importance in engineering and commercial life both at home and in all countries bordering the Pacific.

Improved Engineering and Banking Facilities

The recent authorization given the Federal Reserve Bank of New York to appoint the Bank of England as its agent in London and the probable appointment of the Bank of France as agent in Paris, and other foreign agents through Europe in all likelihood will be followed in time by the appointment of strong financial institutions in similar capacities in Japan, China and Australia. In South America, too, the American banking facilities have long kept back American commercial and engineering enterprise. It is to be hoped the authorization of branch banks will be made in this direction also.

In normal times the arrangement above perfected with European institutions will undoubtedly add much in stabilizing exchange rates and preventing the movement of gold.

But now is the time for better banking facilities with countries bordering the Pacific. As pointed out in a recent issue of the Western Banker and Financier, increased financial facilities with countries bordering the Pacific will probably be far more effective at this time than at the close of the war. Bankers in these countries are still making their bills of exchange on London and it is with a view toward diverting a part of this business to the United States, that the establishment of agencies in Pacific lands is at present informally under consideration.

The strong financial institutions of San Francisco, Los Angeles, Portland and Seattle can aid much in forwarding closer engineering and commercial relations with these countries if only given the opportunity. The problem before the West is the arousing of sufficient public sentiment to stir the national board to action. And careful reasonable public expression on the part of engineers of the West urging the establishment of these Pacific branches will add its share in bringing about this commercial freedom so necessary for growth of Western commercial and engineering enterprise.

Why the Pacific Coast Section of N. E. L. A.

Now that the campaign for new members for the Pacific Coast Section of N. E. L. A. is well under way, it is not amiss for all interested to stop a moment and weigh the reasons that are impelling men of highest engineering and executive ability in the West to support this movement.

The peculiar engineering and commercial problems that exist West of the Rocky Mountains, so wholly different from those that prevail in the more populous districts to the east, are the all impelling motives that lead these men to action.

In this section of the country the insulation problems, the standardization of transformers, the specifications for overhead construction, and many other questions of engineering and commercial interest are so at variance with Eastern practice that in some instances Eastern manufacturers have classified apparatus furnished as "special." Indeed it has not been infrequent in occurrence that questions with answer blanks sent out from the New York office as thought to represent common practice in the electrical industry have proven so foreign to Pacific Coast practice as to prove wholly unanswerable due to non-use of the methods indicated in the forms.

Then again there is the matter of close co-operation of neighboring companies and an over and above board medium for frank comparison of methods and ideals to be realized. The company section has proved too "in-breeding" to attain the broad results desired. The geographical section on the other hand combines close proximity and its consequent community of interest with sufficient instilling of fresh outside thought. Under this method of organization all problems under discussion reach an ideal setting hardly realizable under any other method of organization of sub-sections of the national association.

Those having in charge the fathering of this movement are preparing two main committees for action —the commercial and the engineering. The membership committee, constituting a third necessary division of effort is now actively engaged in gathering in new enthusiasts for the discussions to come later.

The organization proposed is good and wholesome. It has the backing of those who have the interests of the electrical industry of the West nearest at heart. Are you doing your part?

The Possibilities of Regenerative Application

The beautiful results of regenerative braking that are daily being accomplished on the Rocky Mountain Division of the Chicago, Milwaukee and Puget Sound Railway through Idaho and Montana are not only gratifying to the proponents of the scheme but indeed every thoughtful engineer can now sense a wonderful unfoldment for the future in contemplating the enormous possibilities of regenerative application.

Regenerative application in its simplest analysis is the science or art of regenerating electrical energy where otherwise this energy would be dissipated in the form of heat and find no useful purpose. As applied to the railroad the momentum of the cars on down grades is made use of to pump energy back into the transmission system. This not only saves energies that would be otherwise dissipated but a new and ideally perfect system of braking is brought about. In saving of shoes alone for the brakes as ordinarily used an item of gigantic economy is brought about. Travellers who have passed over this road during the past season are enthusiastic over its unqualified success. So much so that the railway officials have recently announced a vast extension of this service to other portions of their system.

Looking about us it is not easy to see in the near future untold extensions of regenerative application that will broaden the present consumption of electricity by leaps and bounds although upon first analysis the reverse might be thought to be true.

Take the case of the automobile. At present operated by gas no possibility is offered for saving that great percentage of waste that is taken up in braking. However, by application to electric vehicles the regenerative principle will undoubtedly prove so saving and economical in the near future as to make this kind of propulsion superior and more economic than its great rival—the gas-operated car.

In ocean-going vessels, the principle will also find untold application. The electric drive now so universally popular can be used to regenerate power and make a saving in operation and also a far more delicate control in backing up and going forward can be brought about.

The future is indeed bright for the great principle of regenerative application and engineers of the West, where a brilliant future awaits its installation on all sides, will follow its evolution with the keenest interest.

PERSONALS

Guy C. Bailey, an electrical engineer of San Francisco, is installing a power plant in the Yosemite.

A. G. Wishon, general manager of the San Joaquin Light & Power Company, was a recent business visitor at San Francisco.

John A. Newland, purchasing agent for the San Joaquin Light & Power Company, was at San Francisco a few days last week.

L. W. Hunt, sales manager for the Commercial Electric Supply Company of St. Louis is a recent visitor on the Pacific Coast.

V. L. Crawford, general representative of Hubbard & Company of St. Louis has been a recent visitor in San Francisco and other coast cities.

D. E. Harris, vice-president of the Pacific States Electric Company, recently returned to San Francisco from a short business trip to Los Angeles.

J. B. Estabrook, secretary and sales manager of the Peerless Electric Company, Warren, Ohio, is a recent business visitor at San Francisco.

F. W. Slater of the turbine department of the General Electric Company of Schenectady, recently left for Los Angeles, on his return trip East.

E. Simon, radio expert, of New York, was a recent visitor at Los Angeles, where he was testing out his own apparatus on the government aeroplanes.

A. H. Halloran, vice-president and managing editor of the Journal of Electricity, has returned to San Francisco after a six weeks' visit in Arizona and New Mexico.

Dr. L. W. Austin, government radio inspector, recently arrived in San Francisco, after inspecting the Chollis Heights Radio Station, San Diego, on behalf of the U. S. Navy.

C. R. Hunt, branch manager of Robbins & Myers Company of San Francisco, recently returned from an extended business trip throughout the southern part of the state.

J. W. Foster, chief alternating current engineer of the General Electric Company, of Schenectady, in company with Mrs. Foster, recently left San Francisco for the Northwest on his return East.

Waldo C. Cole, of the promotion department of the Westinghouse Electric & Mfg. Co. recently returned to San Francisco after an extended trip through the San Joaquin Valley in behalf of that department.

Dr. Morton G. Lloyd, formerly technical editor of the Electrical Review and Western Electrician, has accepted a temporary appointment as associate engineer in the Bureau of Standards, Washington, D. C.

O. Fujinami, electrical engineer of the Nagoya Electric Light Company, of Nagoya, Japan, is a recent arrival in San Francisco, where he will start on a tour of the United States to study the American electrical development.

Wm. Mulholland, chief engineer of the Los Angeles aqueduct, was a recent visitor at San Francisco, where he testified before the railroad commission, in behalf of the Peoples Water Company's rates in Oakland, California.

W. D'A. Ryan, lighting expert of the General Electric Company, who has been located for the past few months at Los Angeles, where he has been designing a street lighting system which is expected to be installed in the next few months, was a recent visitor at San Francisco.

H. C. Vensano has resigned as civil and hydraulic engineer of the Pacific Gas & Electric Company to form an association of contracting engineers with John R. and Edward G. Cahill under the firm name of the Cahill-Vensano Company with headquarters at 460 Montgomery street, San Francisco.

Rudolph Strauch, of the Pacific Gas & Electric Company, and **Fred Baker,** new business manager of the Sierra & San Francisco Power Company, who are a sub-committee of the Range Committee of the N. E. L. A., recently held a meeting at the offices of the Westinghouse Company at San Francisco.

B. E. Topiis, engineer of the British Westinghouse Company of Manchester, England, recently returned to San Francisco, after studying the conditions in the oil fields of California, and will start for the British East Indies, where he will superintend the installation of the electrical machinery in the oil fields at Burma.

J. E. Davidson, vice-president and general manager of the Pacific Power & Light Company, has resigned to accept a position with the Electric Bond & Share Company of New York. His first detail will be at Omaha where he will be connected with the Amaha Electric Light & Power Company. **John A. Laing,** who has been acting as general attorney for the company and **Lewis A. McArthur,** assistant general manager will be the new vice-president and general manager, respectively.

J. C. Holbrecht, an electrical contractor of Sacramento; **J. A. Crandson,** Portland manager of the General Electric Company; **E. C. Stoner,** manager of the Julien Electric Company of Atascadero; **Geo. Sanford,** manager of the Great Western Power Company of Rio Vista; **W. A. Ough,** manager of the Plumas Light & Power Company of Greenville, Plumas County; **J. C. Thirlwall** of the railroad department of the General Electric Company of Schenectady; **A. F. Dickerson,** lighting expert of the General Electric Company, with W. D'A. Ryan of Los Angeles; and **A. F. Flannagan,** proprietor of the Engineering Electrical Supply Company at Stockton were recent business visitors at San Francisco.

BOOK REVIEW.

Principles of the Telephone—Part 1, Subscriber's Apparatus. By Cyril M. Tansky, B. S., B. A., and Daniel C. Faber, E. E. Size 6 by 9 in; 160 pp.; 125 illustrations; cloth binding. Published by McGraw-Hill Book Company, Inc., of New York City, and for sale at the Technical Book Shop, San Francisco. Price $1.50.

This book is the first of a series that is being prepared in the extension division of the University of Wisconsin, in which university the authors are connected with the electrical engineering faculty.

The text has been designed to be of practical use to men who are actively engaged in the installation, care, and operation of telephone apparatus. Although details of construction are not given to any extent, the authors set forth clearly the principles that underlie good construction. The treatment covers such subjects as elementary electrical principles, magnetic principles and sound. It then proceeds to discuss transmitters, receivers, induction coils and signalling apparatus with discussions of the subscriber's telephone set. The chapters relating to faults in substation, protection of telephone lines and apparatus and their installation are especially helpful. A series of questions is appended at the end of each chapter that assist the beginner in fixing the points brought out in the text. The book should find a welcome reception among men desiring a clear practical treatment of the subject matter involved.

MEETING NOTICES FOR ELECTRICAL MEN

(The continual getting together of engineers of the West is having a marked effect in not only cementing friendships but in immeasurably heightening the usefulness of the engineer and his profession. In the following lines are recorded meetings of interest to electrical men that have taken place in the past two week period in various localities of the West.—The Editor.)

San Francisco Electrical Development and Jovian League

Grayson Harrison of the Fireman's Fund Insurance Company, San Francisco, was the speaker of the day at the February 14th meeting of the League. Mr. Harrison was introduced by D. E. Harris, who acted as chairman of the day. The speaker gave an interesting talk on the history of insurance, and the growth and development of the great insurance firm of Lloyds of England. President Newbert appointed Messrs. E. M. Cutting, R. F. Behan, P. Decker, A. Meinema and J. C. Manchester as a nominating committee to present a list of candidates at the next business meeting for the various offices of the league to serve for the new term.

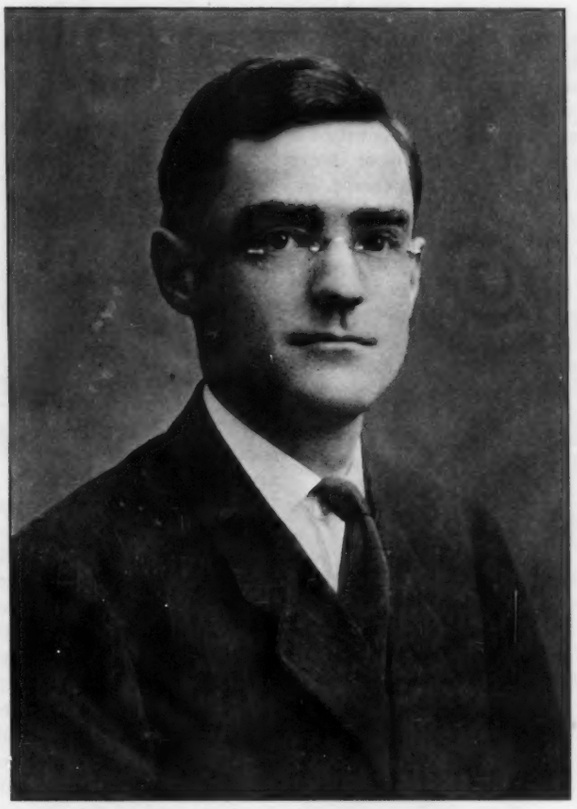
The meeting of February 21st was devoted to an interesting paper given by Roy Bishop on the modern traffic problems of railroading. Mr. Holland of the Great Western Power Company acted as chairman of the day.

Bi-Weekly Luncheon of the Joint Local Sections of the A.I.E.E. and N.E.L.A. with the Oregon Society of Engineers.

This meeting was held in the orange room of the Oregon Hotel, Wednesday noon, February 14th.

The chairman of the day was A. S. Moody and the program was turned into a farewell luncheon to J. E. Davidson, past chairman of the Portland Section, N. E. L. A., who is leaving Portland to accept an executive position with the Electric Bond & Share Company of New York.

J. A. Laing, the new vice-president of the Pacific Power & Light Company, gave a short talk on Mr. Davidson's record. A. S. Griener, vice-president of the American Power & Light Company, New York, Dr. F. W. Vincent, local manager Portland Power & Light Company, Pendleton, Oregon, and B. P. Bailey, local manager Portland Power & Light Company, The Dalles, Oregon, were also guests of honor at this luncheon. The attendance was seventy-three.



Lewis A. McArthur, the New General Manager of Pacific Power & Light Company

Portland Sections of N. E. L. A. and A. I. E. E.

The regular joint meeting of the local sections of the A. I. E. E. and the N. E. L. A. was held in the Assembly Hall of the Multnomah Hotel, Tuesday evening, February 6th. The chairman of the evening was J. C. Hinkle. The speaker was Prof. W. C. Morgan of Reed College on "The New Chemical Element—Electricity." This talk was illustrated by lantern slides. Prof. Morgan said in part: "At present the great scientists are debating the question of the 'constitution of an atom,' and many of the old theories are completely upset, but as yet the new ones are so vague that no one understands them." The attendance was seventy-two.

Oregon Society of Engineers

The annual banquet and election of officers of the Oregon Society of Engineers took place at the University Club, Monday at 6:30 p. m., Feb. 5, 1917, many scientific and technical men attending. The new officers who will manage the affairs of the organization for the ensuing year are as follows: H. L. Vorse, president; J. P. Newell, vice-president; Orrin E. Stanley, secretary; Henry M. Morse, treasurer; J. W. Cunningham, L. F. Harza and O. Laurgaard, directors; R. E. Cushman, R. G. Dieck, R. J. Grace, W. P. Hardesty, H. B. Hastings, C. P. Keyser, H. E. Plummer and Harold A. Rands, nominating committee.

The secretary reported that there had been obtained 56 new members during the year and that there was $1028.70 on hand in the bank.

Prof. Frank Laxley Griffin of Reed College discussed Prof. Otto B. Goldman's article, published in the Journal of the Oregon Society of Engineers, Vol. 3, on "The Engineer and Mathematics." Prof. F. L. Griffin said that he heartily endorsed everything in the paper and that he was endeavoring in his own work to carry out some of the methods suggested by Prof. Goldman.

Other discussions of the evening were as follows: J. P. Newell discussed House Bill 213, relating to the state road work. Dr. W. F. Amos discussed "Vaccination." Prof. Otto B. Goldman discussed and severely criticized Clyde B. Aitchison's "Cost of Service Analysis in Public Utility Rate Cases," published in Vol. I of the Journal of the Oregon Society of Engineers.

Prof. Goldman contended that this article is absolutely inconsistent in its arguments and will not bear a close analysis. He again referred to his paper on "The Multiple Rate and Cost System," first published in the Journal of Electricity, and again published in the 1915 Transactions of the A. I. E. E., and stated that now, after two years, no one had endeavored to criticize it. Messrs. Rockwood, Thompson and Colby also entered into the discussion. Seventy members were in attendance.

TRADE NOTES

Hampton Electric Company, formerly at 502 Mission street, recently moved to larger quarters located at 518-22 Mission street, under the name of Hampton Electric & Machinery Company.

Combining effectiveness of selling features with simplicity of design, the display window of the Bristol (Tenn.-Va.) Gas & Electric Company took first prize in the National Mazda

window contest conducted during November and December. The Doherty Company triumphed over 1886 competitors. The display was the idea of W. B. McSpadden, new business representative.

In order to definitely handle the large amount of raw material necessary in the manufacture and production of "Century" apparatus, the Century Electric Company of St. Louis, Mo., has let a contract for the erection of a reinforced concrete warehouse containing some 15,000 square feet of floor space with terminal facilities and designed with special reference to handling sheet steel, shaft stock and other raw material. The warehouse when completed will be equipped with all of the up-to-date appliances for handling heavy material, such as jib and traveling cranes.

The following changes and additions to the organization of the Century Electric Company have recently been made: G. Y. Watt, formerly in charge of the Rochester office of the Century Electric Company, has now been transferred to the new sales office opened at 10 High street, Boston, Mass. He will be assisted by J. F. Elliott and H. P. Westervelt. G. H. Lindsey, formerly connected with the St. Louis Office, has been placed in charge of the Rochester Sales Office, 525 Granite Building. The sales organization at St. Louis has been increased by the addition of Mr. E. S. Moore, who will have charge of the Fan Department.

M. G. Jeffress, formerly a practicing attorney of San Francisco, recently purchased the entire interest in W. T. Garratt & Co., the bell and brass foundry, machine shop and hydraulic works, and has given up his law practice to take up the active management of the company. W. T. Garratt & Co. has a record of sixty-six years of continuous business, having been established in 1850. As a bell foundry it has held for many years a very prominent position throughout the western half of the United States. The company is also widely known as the manufacturer and owner of the Hooker Pump, and also as the manufacturer of the Garratt Jack Head Pump and the Garratt Deep Well Pump. The two former pumps are used extensively throughout the various mining districts of the West for sinking purposes.

Utility Activity at Stockton

The board of directors of the Western States Gas & Electric Company has declared the regular quarterly dividend of 1¾ per cent on the preferred capital stock of the company, payable January 15 to stockholders of record December 30th.

New business is being connected by the various divisions in steadily increasing ratio. At Stockton the Holt Manufacturing Company has completed an additional machine shop which will be electrically operated. The Western States Gas & Electric Company supplies the electrical requirements of this concern amounting at the present time to 750 h.p. The new machine shop will require in the neighborhood of 250 h.p. additional. A contract has been closed by the company with the Samson Sieve-Grip Tractor Company for 200 h.p. in motors in addition to the 241 h.p. now being furnished. The Samson company is doubling its output, the plant being operated day and night.

TRADE OPPORTUNITIES IN PACIFIC LANDS.

Details concerning the foreign trade opportunities listed below may be obtained by addressing the United States Department of Commerce at Washington, D. C.:

A man in Colombia wishes to get in communication with manufacturers of machinery for making mosaic and floor tile.

A firm in Chile wishes to secure an agency for the sale of motor-truck chassis, with a four-wheel drive. Quotations should be made f. o. b. New York. Cash will be paid. Correspondence may be in English. References.

A man in Chile is in the market for a universal milling machine, suitable for making all kinds of automobile gears and capable of doing a great variety of other work. Correspondence should be in Spanish. Reference.

A man in Brazil desires to receive prices from American manufacturers and exporters of general merchandise, hardware novelties paper, etc. He has submitted a complete list of articles wanted, a copy of which may be obtained from the Bureau or its District Offices.

The representative of a firm which does business in Argentine, Paraguay, and Uruguay has opened an office in New York and desires to secure agencies from American manufacturers and exporters of cotton piece goods, such as drills, printed shirtings, tickings, etc. References.

A firm in Chile is in the market for printing and lithographing inks for stock and sale. Quotations should be made c. i. f. destination. References. Correspondence preferred in Spanish, but may be in English.

NEW BULLETINS

The analytical distillation of petroleum is the subject matter of Bulletin 125, just published by the United States Bureau of Mines.

Pass & Seymour, Inc., of New York City, has just issued catalog Number 24 for 1916-1917, entitled Handy Electric Wiring Devices which should prove of much practical value to the contractor and dealer.

The tractive resistance on curves of a twenty-eight ton electric car is discussed by Edward C. Schmidt and Harold H. Dunn in bulletin 92 of the Engineering Experiment Station of the University of Illinois.

Technical paper 118 of the Bureau of Mines, just issued, is a thirty-six page pamphlet on the very important discussion of suggested safety rules for installing and using electrical equipment in bituminous coal mines.

The uses of open heaters in connection with the heating, metering and softening of water for boiler and other purposes are exhaustively treated in a 100-page book (Publication No. 710) lately issued by the Harrison Safety Boiler Works, Philadelphia, Pa.

Bulletin No. 3 of the State Highway Commission of Oregon has recently been issued. The bulletin is in the nature of a bridge manual and contains standards, general information and instructions regarding highway construction that are of much value to highway engineers.

Three four-page envelope enclosures have just been published by the Cutler-Hammer Manufacturing Company of Milwaukee, describing C-H electric laundry irons, C-H electric tailors' irons and C-H electric soldering irons respectively. The folder concerning laundry irons lists irons of two weights most convenient for domestic use.

Bulletin 74 of the Bureau of Standards deals with an investigation of cartridge-inclosed fuses. In substance it is a report of the Bureau of Standards in the case of Economy Fuse & Manufacturing Company vs. Underwriters' Laboratories (Inc.), concerning the fire and accident hazard of the Economy refillable fuse as compared with approved fuses.

The tractive resistance on curves of a 28-ton electric car has been made the subject of a study by the railway department of the Engineering Experiment Station of the University of Illinois. The results which are set forth in Bulletin No. 92 of the station establish, for this car, the relation between curve resistance and speed, and between curve resistance and rate of curvature; the ratio in both cases is direct.

An unusually artistic and striking piece of publicity has just been issued by the Westinghouse Electric & Manufacturing Company, entitled "Get This Crowd Headed Your Way With——" and "Westinghouse—the Value of the Name." The latter publication is 12 by 14 in. and contains a number of striking pages of beautifully illustrated matter on electrical appliances in the home, recently featured in the magazines of America.

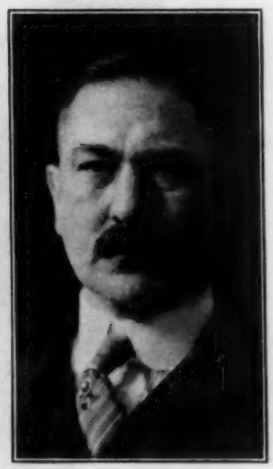
LATEST IN EVERYTHING ELECTRICAL

(Industrial activity in affairs electrical are recorded from several distinct fields of activity in the following pages. A new power factor meter, the announcement of gigantic enlargement of the Westinghouse plant, window display prizes, electrical appliances on the Mexican border, together with descriptions of new electric stoves, coffee grinders, potentiometers and the like constitute the further items of interest set forth.—The Editor.)

A NEW WESTERN FIRM OF MANUFACTURERS' AGENTS

Garland-Affolter Engineering Company, 315 Rialto Building, San Francisco, representing as district managers the Moloney Electric Company for California, Nevada and Arizona, in the sale of transformers; the Peerless Electric Company for the territory west of Salt Lake City and Helena,

P. H. Affolter



A. E. Garland

Montana, in the sale of single-phase motors and other electric apparatus manufactured by them; the Howell Electric Motors Company, the same territory for the sale of polyphase motors; this firm also will represent on the coast the Allen-Bradley Company and the Union Electric Manufacturing Company, manufacturers of motor control apparatus and automobile charging switchboards.

P. H. Affolter has been for the past six years manager of the electrical department of the San Francisco office of Fairbanks, Morse & Company, having previously been designing engineer for the Western Electric Company, at their Hawthorne Works at Chicago.

A. E. Garland has also been with Fairbanks, Morse & Company for the past ten years, the last five of which were spent among their various branches as traveling electrical engineer. Previous to this he was engaged for a number of years in the manufacturing of electrical apparatus.

The Journal extends its congratulations to the manufacturers represented by this new Western firm, and its best wishes to the Garland-Affolter Engineering Company.

NEW WESTINGHOUSE PLANT

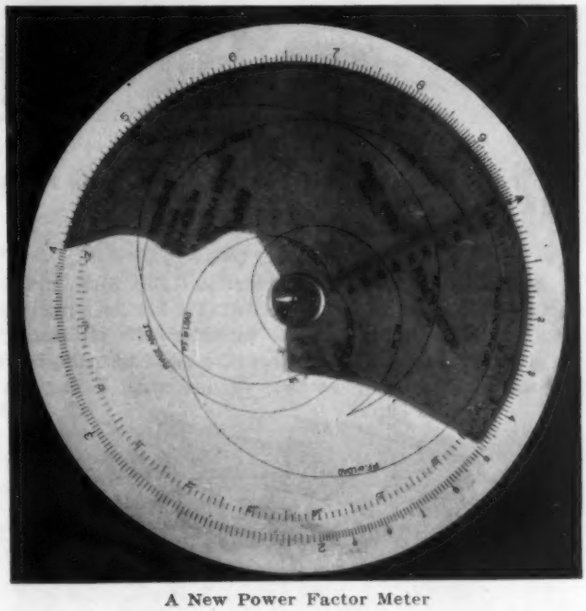
Announcement has just been made by the Westinghouse Electric & Manufacturing Company that the plot of ground recently purchased at Essington, near Philadelphia, will form a new industrial center for the Westinghouse Electric interests. The site embraces about 500 acres, with a frontage of approximately one mile on the Delaware River. Additional transportation facilities will be afforded by tracks from the Pennsylvania and Philadelphia and Reading Railroads.

This new center will be devoted to the production of large apparatus, the first group of buildings being for power machinery, principally steam turbines, condensers and reduction gears. The initial development will cost in the neighborhood of $5,000,000 or $6,000,000 occupying about one-fifth of the area of the entire plot. The group will consist of the following buildindgs: two large machine shops, an erecting shop for heavy machinery, forge shop, pattern and pattern-storage shop, and power house. Work will begin on these as soon as satisfactory building contracts can be let.

The number of employes to be engaged at the new plant has not as yet been definitely determined but will number several thousand people, and undoubtedly will in the future equal the number employed at East Pitsburgh, representing over 20,000 people.

A NEW POWER FACTOR METER

Messrs. Hoag & Backstrand of Riverside, California, have recently perfected a new power factor meter. A circular plot shown in the background has superimposed upon it a celluloid



A New Power Factor Meter

scale shown in section in the illustration. By revolving the celluloid scale in front the power factor is at once ascertained from the curves ploted upon the background. The meter is sold for a dollar, and may be purchased by addressing the Technical Book Shop, San Francisco.

NEW BULLETINS

Pass & Seymour, Inc., of Salvay, N. Y., has just issued form 1105 on P. & S. chain pull candle-fixture sockets.

Bulletin 162 of the Electric Storage Battery Company discusses the progress made in their buildings since June 1916.

Experimental researches on skin effect in steel rails are set forth in bulletin 12 by A. E. Kennelly and others of the research division of the electrical engineering department at the Massachusetts Institute of Technology.

ELECTRICAL APPLIANCES FOR OUR SOLDIERS.

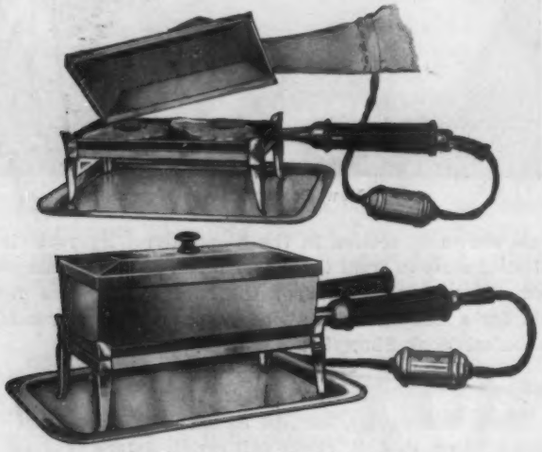
Down on the border line of Mexico the boys are making use of the latest appliances of electrical design to lessen the drudgery of work. Here is an illustration of a day in

Doing It Electrically on the Border

camp that softens the hue of the sky when "blue Monday" comes around.

NEW TABLE STOVES

The new C-H Electric Combination Table Stove made by the Cutler-Hammer Mfg. Co. of Milwaukee has been tested and put upon the market. With this versatile little appliance you can sit at the table and cook an entire meal with the current from an ordinary lamp socket. In one small oblong stand,



The New Electric Table Stove

on four slim little legs, you have a frying pan, griddle, toaster, broiler, saucepan and small oven.

The heater is made of two sheet steel plates which are welded together and inclose the heating elements. This can be placed above or below the cooking vessels, according to the type of cooking demanded.

COLES ELECTRIC COFFEE MILLS

The coffee mills and the combination mill and meat grinder shown are new models that have been placed on the market by the Coles Manufacturing Company of Philadelphia, Pa. The small mill will granulate a pound of coffee in forty seconds and can be connected to the ordinary electric light socket. It is operated by a ¼ h.p. Westinghouse motor. This mill has obstruction release to clear grinders; an indicating regulator which provides for six grades of coffee; a detachable hand crank for hand operation of the mill should current fail, and a self-cleaner and dust-proof pan. It occupies a counter space of 12 by 17 inches, and is 27 inches high.

Combination Coffee Mill and Meat Grinder

The double mill will granulate five pounds of coffee per minute or pulverize one pound per minute. It is operated by a ¾ h.p. Westinghouse motor. The motor operates both grinders at the same time. This mill has an automatic releasing and resetting device, self-cleaning heads, dustproof pans, indicating regulator which provides for twenty grades of coffee, and six pound nickel hoppers. It is furnished for mounting on the counter or with pedestal base for floor mounting.

The combination coffee mill and meat chopper has a capacity of 8 pounds of beef per minute, or will granulate two pounds of coffee per minute. It is operated by a ¾ h.p. Westinghouse motor. All parts, including the bowl are removable. The regular equipment consists of four sets of knives and plates, one sausage stuffing attachment, meat pusher, spanner wrench for chopper ring. Bone grinder, pulley, or tool grinder also furnished when desired. It is furnished for mounting on the counter or with pedestal base for floor mounting. It occupies a counter space 20 by 32 inches and is 36 inches high.

Such appliances and labor saving devices as these are immeasurably increasing the efficiency of modern routine work in the trades.

$1250 CONTEST FOR WIRING CONTRACT SOLICITORS

Cash prizes aggregating $1250 to be awarded by the Society for Electrical Development in annual "Wire Your Home Time" campaign, April 1st to May 15th. Committee meets and decides on plans for spring housewiring drive.

The Society for Electrical Development has announced a $1250 cash prize campaign to salesmen in connection with its annual spring housewiring drive, April 1st to May 15th.

The contest is open to all housewiring contract solicitors employed by central stations or contractors who are members of the society.

The country will be divided for campaign purposes according to population so that cities and towns of nearly equal size will have equitable chance of competition. Under the plan as arranged the prize money will be divided equally between five classes:

1. Cities of 15,000 or under.
2. Cities of between 15,000 and 50,000.
3. Cities between 50,000 and 100,000.
4. Cities of between 100,000 and 500,000.
5. Cities of 500,000 and over.

POTENTIOMETER FOR "HOT SPOT" TEMPERATURE MEASUREMENT.

The importance of knowing the temperature of the hottest part in electrical machines is now well recognized. The most accurate and reliable method of measuring temperature in parts of machines inaccessible to thermometers, is by means of a thermo-electric couple. The practice of building

Improved Potentiometer for "Hot Point" Temperature Measurement

such couples into the windings of large machines at points where the highest temperatures are reached, though of comparatively recent origin, is fast becoming standard. The thermo-electric couple is found to be more reliable than copper wire pyrometer or search coils sometimes employed, for the reason that the necessarily delicate construction and insulation of such coils render them liable to undetected damage during construction, or destruction of the insulation due to service conditions.

For measuring the temperature at a point where a thermo-electric couple has been installed a potentiometer is utilized. This instrument balances the electromotive force of the couple under test against that of another couple at known temperature. This avoids all errors due to variation in leads, etc., and as all indications are on the "Null" or zero reading principle, very accurate readings are obtained. The reading is given directly in degrees, Centigrade. By using a dial switch, any number of thermocouples on one machine or on several, can be read at will with one potentiometer at any desired location.

SUGGESTIVE HINTS FOR DEALERS

Here is the latest thing electrical in the way of suggestions to aid dealers in increasing electrical appliance

This is for Men Folks!

To you, Mr. Man, who are in the habit of eating your breakfast alone, while your wife is running back and forth to the kitchen—picture this little scene:

sales. This is a suggestion sent out by the Society of Electrical Development to assist sales service in electrical appliances.

CONTESTS OF NATIONAL LAMP WORKS

The National Lamp Works of Cleveland has awarded the first prize, a Ford Touring Car, for its annual window dis-

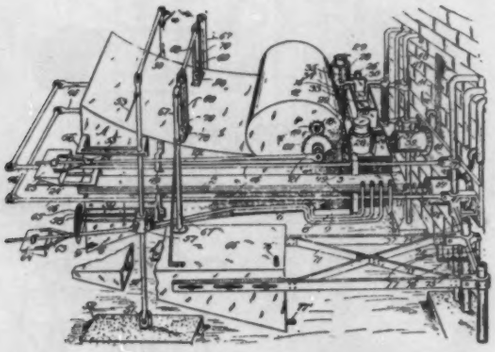
The First Prize Setting for the National Lamp Works Contest

play contest to W. R. McApodden of the Bristol Gas & Electric Company, Bristol, Tenn. The simplicity, yet effective manner in which the display is brought out is wonderfully apparent in the illustration shown herewith.

WHAT WESTERN INVENTORS ARE DOING

(Great practical application throughout the West could be put to efficient creation for making use of wave-force and low heads of running water. Two inventions are herein recorded looking toward the utilization of these latent energies. Electric cooking and wireless telegraphy also come in for description, due to recent activity of Western inventors along these lines.—The Editor.)

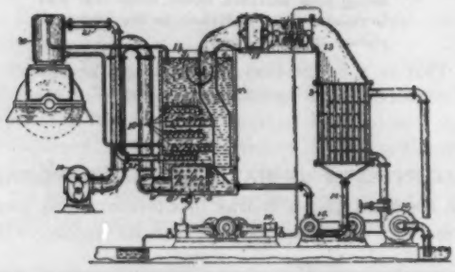
1,214,257. **Wave-Force-Utilizing Device.** Emmer B. Arnold, Los Angeles, Cal.



A device for utilizing the force of waves, comprising an inclosure having a water cushioning chamber, and a plurality of outlets beyond said chamber.

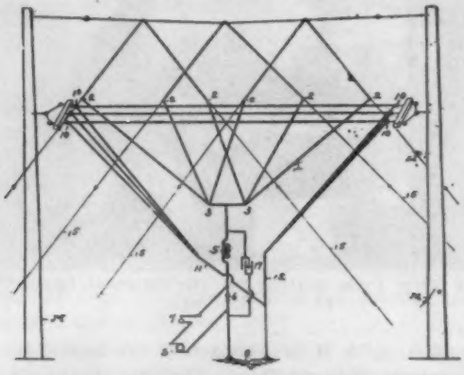
1,214,103. **Power-Generating Apparatus.** Fred L. Williams, San Francisco, Cal.

A power-generating apparatus comprising an open-ended boiler adapted to contain water, means for passing a heating medium through the boiler and out the open end thereof



for heating water, a steam-operated, power-generating unit, and a pipe connected with the inlet side of the unit, said and a pipe connected with the inlet side of the unit, sai pipe having its opposite end submerged in the water contained in the boiler.

1,214,283. **Wireless Telegraphy.** Lee de Forest, Palo Alto,

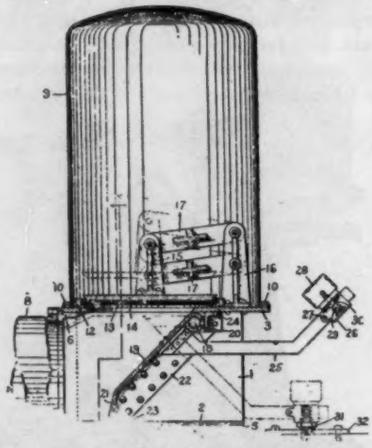


Cal., assignor to Federal Telegraph Company, a corporation, of California.

A transmission system for wireless communication, an elevated fan-shaped main antenna, a conductor connecting said antenna to earth, an inductance and a source of electrical oscillations in said conductor, a supplementary horizontal antenna arranged within and insulated from said main antenna and a conductor connecting said supplementary antenna to earth.

1,214,192. **Hydraulic Ram.** John E. Lester, Tacoma, Wash.

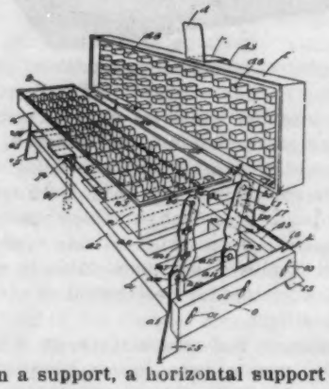
A hydraulic ram, a supply pipe, a casing connected therewith and having a direct horizontal passage alined with the supply pipe, a waste-valve pivotally mounted in the casing and swingable from an open position substantially parallel with the horizontal passage to a closed position extending angularly across said passage, a delivery-valve controlling a lat-



eral outlet from the horizontal passage adjacent to that edge of the waste-valve which is farthest from the supply pipe, and means connected with the waste-valve and tending to swing the same toward the open position thereof.

1,214,486. **Electric Cooking Apparatus.** William D. Wright, San Diego, Cal.

A device of the kind described, a grill member mounted



at each end on a support, a horizontal support parallel to the grill member mounted at each end of one of the supports, a plurality of swinging arms each mounted at one end on extended portions of the first named supports, a waffle member pivotally mounted on the other ends.

NEW ELECTRICAL DEVELOPMENTS

(The greatest new development of the past two week period in the West seems to be along the line of increased activity in conserving water for storage. This water is to be used both for hydroelectric and domestic supply purposes. Instances of these dams under way are to be found in the front pages of this issue. In the following items are noted many new electrical developments now in progress in various sections of the West.—The Editor.)

FINANCIAL

SAN FRANCISCO, CAL.—American telephone companies had a total revenue of $24,976,258 for October last, an increase of nearly 14 per cent over the previous, according to statistics made public by the I. C. C. Net operating income for the month was $6,920,199, nearly 30 per cent of the total revenue. The total number of telephones operated by the reporting companies was 7,080,314, an increase of 609,817, or about 1 0per cent over 1915. While operating revenues increased about 14 per cent, expenses increased approximately 15½ per cent. For the tenth month ending with October returns to the commission show that the companies received total revenues of $234,377,047, an increase of nearly 12 per cent over the previous year, of which $65,823,632 was net operating income.

ILLUMINATION

SANTA BARBARA, CAL.—The F. E. Newberry Company of Los Angeles was awarded the contracts for ornamental light installation in both districts on State street.

SONORA, CAL.—An election will be called soon to pass on the proposition for establishing an underground municipal lighting system. The system is estimated to cost about $20,000.

MARYSVILLE, CAL.—The Meridian Ladies' Embroidery Club is circulating a petition which will be submitted to the board of supervisors at the next meeting. The petition asks the supervisors to call an election for the installation of a lighting system for the town of Meridian.

SALINAS, CAL.—The electrolier committee of the Chamber of Commerce and City Council agreed to turn the matter over to lighting expert C. F. Phillips. At a meeting of the council Mr. Phillips will be authorized to go ahead with estimates relating to the installation of electrolier system.

SAWTELLE, CAL.—Application has been made by the Beverly Hills Utilities Company to the board of trustees of the city of Beverly Hills for a franchise granting a right for a period of 40 years to construct and operate a system of pipe lines in certain public streets, for the purpose of supplying gas. Sealed bids will be received at the office of the city clerk.

LOMPOC, CAL.—That the Continental Securities Company, holders of the controlling interest in the Lompoc Light & Power Company are again negotiating for the sale of the local light plant to the Midland Counties Public Service Corporation has become known. According to officials of the Midland Company no purchase will result, as the owners of the local plant are holding out for too high a figure.

TRANSMISSION

RITZVILLE, WASH.—William H. Galvani, a civil engineer of Portland, connected with the Pacific Power & Light Company, has been negotiating with the county commissioners relative to a right of way for power lines in Adams County.

QUINCY, CAL.—The Indian Valley Railroad Company has sold to the Great Western Power Company its right of way for the construction of an electric transmission line along the railroad right of way between Paxton Station and Engel's Copper Mine.

YREKA, CAL.—The California-Oregon Power Company has closed a contract to extend a power line to the Konrad Holfelder ranch south of Montague for a pumping plant of Hudson & Edmonds. These men intend to irrigate a large area of land in that vicinity.

LOS ANGELES, CAL.—For right-of-way for its power transmission line through the Ivanhoe district, the city will be required to pay an aggregate of $6175. This is the last link in the 45 miles of right-of-way the city will require in its power project, connecting power plant in San Francisquito canyon with the central substation in East Los Angeles.

SAN BERNARDINO, CAL.—For the purpose of launching a campaign to secure a municipal light and power plant, or at least a distributing system for light and power here, a public meeting has been called. It is predicted that a municipally owned plant for light and power will be one of the big issues of the coming spring election.

BOISE, IDAHO.—The appropriations committee of the house of representatives may visit the Gem irrigation district soon for the purpose of investigating the merits of the bill introduced providing for an appropriation of $3000 for a power plant to generate electricity for the pumping of water to lands within the project.

SALEM, ORE.—The Portland Railway, Light & Power Company has recently commenced the construction of a new 60,000-volt electric power transmission line to Salem from what is known as their River Mill hydroelectric plant, near Estacada. This line will supply power to Salem and to the substation at Mill and Liberty streets. The expense involved in bringing this new line into Salem will be about $40,000.

BEND, ORE.—Kempster B. Miller stated that improvements would be made next winter to the Bend Water, Light & Power Company plant, which will cost between $50,000 and $75,000. An addition will be built to the power unit, and the balance of the work will go on the water and electrical distribution systems extensions. Mr. Miller is engineer for the company.

TACOMA, WASH.—Steps are being taken for the construction of additional facilities for increasing the capacity of the municipal power plant and a new auxiliary steam plant to cost $300,000 instead of a new hydroelectric plant to cost $3,000,000. Commissioner of Light and Water Gronen and City Attorney Harmon are now drafting a resolution which will bring the proposition before the taxpayers. An engineer will be appointed at once to make an investigation.

PARKER, ARIZ.—Within the next few months it is probable that the Southern Sierras Company of California will have its transmission lines into Parker, furnishing electrical power for irrigation, lighting and mining. H. N. Seifried, representing the company, has been here seekng data on prospective business for electric power. The company is now building into Yuma and it plans upon putting a transmission line into the Quartzsite country. Another line is being constructed to Barstow. It is probable that the Barstow line may be extended to Parker, and a line run from Blythe Junction to Blythe and Quartzsite.

TRANSPORTATION

HONOLULU, T. H.—Plans for the extension of the track system of the Honolulu Rapid Transit & Land Company will soon be started.

FULLERTON, CAL.—The Board of Trustees has granted the Pacific Electric Company a franchise into Fullerton. To reach Fullerton the company has merely to build from La Habra, a distance of about four miles.

SAN FRANCISCO, CAL.—The board of works is receiving bids for 34,500 pounds of copper trolley wire in two sizes, or a total length of about ten miles, and worth in the neighborhood of $14,000.

WHITTIER, CAL.—Whittier is interested in the development work of the Pacific Electric Railway, and at present a special committee of the Chamber of Commerce is working on the project of the extension of the line through this city. One conference with heads of the company has already been held and some encouragement has been received. It has been understood that the Pacific Electric would build to Riverside and Corona from the Yorba Linda terminal, but recent reports are to the effect that the Corona territory will be reached by a branch line from Pomona.

TELEPHONE

NEWMAN, CAL.—The Pacific Telephone & Telegraph Company has filed with the trustees an application for a franchise. Bids are being received by the city officials.

FRESNO, CAL.—The board of trustees of the Laguna Reclamation District No. 779 announce that the telephone lines owned by the district, extending west and south from Laton a distance of about 11 miles, with equipment, will be sold at public auction on March 8th.

SAN DIEGO, CAL.—Fire has badly damaged the El Cajon branch of the Home Telephone Company and the office is now in operation under a tent. The roof was burned off the building. The switchboard and rack are still on the original floor, with the tent over them in place of the burned roof.

DOUGLAS, ARIZ.—The second leg of the Tucson to El Paso circuit of the Mountain States Telephone & Telegraph Company is nearing completion. When completed the entire circuit, composed of two No. 8 copper wires, will have cost about $145,000. Work on a branch line from Bisbee and Tucson is being pushed rapidly.

KINGMAN, ARIZ.—The Arizona, California & Nevada Telephone Company may shortly link the Weaver district with Kingman by telephone if a report made by the manager of the company's office at Chloride is looked upon favorably by the company. The project wil require the construction of about eight miles of line at an approximate cost of $350.

HANFORD, CAL.—At a meeting held with J. A. Whan, manager of a local exchange for the Pacific Telegraph & Telephone Company, a committee of residents of Delta View district agreed upon plans for the installation of a new telephone line into that part of the country. A company will be organized and a telephone line constructed and operated.

ORANGE, CAL.—The board of trustees is receiving bids for one four-line loop storage battery switchboard, consisting of one manual four-line loop storage battery switchboard enclosed in an oak frame, with necessary storage batteries to operate the fire alarm system; one storage battery rack with necessary glass strips and porcelain insulators and one motor generator set for charging batteries.

IRRIGATION

OLINDA, CAL.—The Happy Valley Irrigation District, which was suspended in 1895, is to be revived. The purpose of the reorganization is to acquire the water rights of the Happy Valley Water Company, purchase more water rights and extend the irrigable field in Happy Valley.

KOOTENAI, IDAHO.—A. H. Featherstone, proprietor of the Bonner Water & Light Company, was in the city looking over the plant and promised considerable improvement in the spring. A new pumping station of concrete will be among the improvements.

LOS ANGELES, CAL.—The East Side Land & Water Company of Los Angeles has applied to the state water commission for permission to appropriate 300 c.f. from Cowhead or Pelican Lake and 125 c.f. from Twelve-mile Creek, in Modoc County, for irrigation purposes.

MEDFORD, ORE.—W. J. Scott of Antioch has proposed the formation of a co-operative community district, to be bonded for the construction of an electric power plant and irrigation system. The district will include 25,000 acres of land in Sams Valley. The priject is estimated to cost about $1,000,000.

DIXON, CAL.—W. J. Wayland has applied to the state water commission to appropriate, for the proposed Dixon Irrigation District, in the vicinity of Dixon, 300,000 to 350,000 acre-feet per annum of the waters of Putah Creek, tributary to the Sacramento River, for the purpose of irrigating 55,000 acres of land.

FRESNO, CAL.—Landowners of Fresno County in mass meeting voted approval of the plans to construct a $9,000,000 reservoir at Pine Flat, Fresno County, to irrigate 1,000,000 acres in Fresno, Tulare and Kings Counties, and a committee will be named to ascertain if the Fresno Irrigation District desires to enter the project. Hydroelectric power for drainage will also be developed.

TURLOCK, CAL.—The board of directors of the Turlock Irrigation District, containing 176,210 acres, is now preparing an estimate of cost for the addition of 2700 more acres, located southwest of and adjoining the Turlock district. The work of draining certain portions of the Turlock Irrigation District is progressing favorably, except in the Tully tract, where quicksand has been encountered. The directors have authorized the purchase of a thousand eucalyptus trees, which will be set out along the various dams of the district as a matter of protection. Water for irrigation will be ready for turning into the canals by February 15th, if needed.

LINDSAY, CAL.—Word has been received here that the State Validating Commission, composed of the Attorney General, State Bank Examiner and State Engineer, had approved and validated the issuance of $1,400,000 bonds for the construction of the Lindsay-Strathmore Irrigation District. This is joyful news for the people of Lindsay as well as those who will come under the proposed project, and the work will now go forward with renewed haste. The contractors announce that they expect to complete the work by next June. The board of directors held a meeting in Los Angeles recently and the returning members confirmed the news of the validation. Approximately one-fourth of the project has already been completed.

SACRAMENTO, CAL.—A petition for the establishment of the Fair Oaks irrigation district under the provisions of the Wright act was presented to the county supervisors. George Bell, resident of the district and member of the water committee, and R. A. Rose, chairman of the water committee, were called as witnesses and testified to the needs of the district and the advantages of the proposed system. The proposed Fair Oaks district includes 3060 acres in Fair Oaks city, Fair Oaks addition, Fair Oaks Park and Fair Oaks tract. It is proposed to purchase water for the district from the North Fork Ditch Company, whose line delivers 28 c.f.p.s. or miners' inches, at the lower penstock reservoir which is ample for the district. The district will purchase and make use of, so far as possible, the pipe lines of the American Irrigation Company, which now is watering the section. A bond issue of $140,000 is proposed for financing the project.